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National Air Quality, Monitoring, and Emissions Trends Report, 1977

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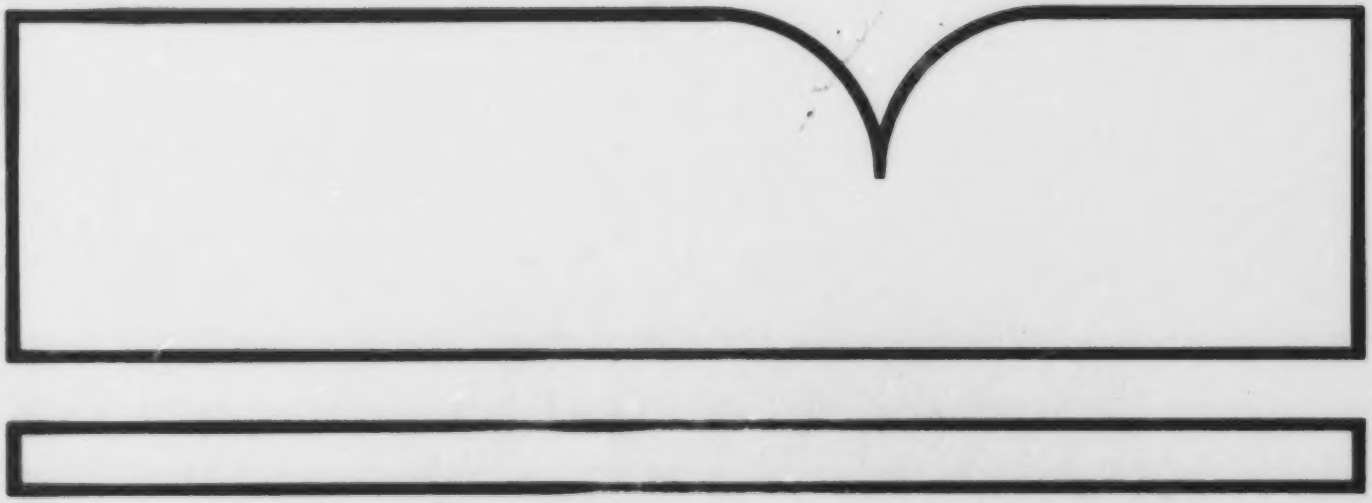

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16. ABSTRACT

This report presents national and regional trends in air quality through 1977 for total suspended particulate, sulfur dioxide, carbon monoxide, nitrogen dioxide and oxidants. The change in the number of people exposed to air quality levels above the National Ambient Air Quality Standards (NAAQS) is emphasized. Changes in air quality levels are discussed for the Nation, the Northeast Corridor, extending from Washington, D.C. to Boston and two selected metropolitan areas: Greater Cleveland and St. Louis.

Air quality monitoring during 1977 is presented in terms of the number of reporting stations by pollutant and measurement method and their status with respect to the NAAQS. A unique feature of this report is the presentation of emission density maps, by county. Nationwide emissions for the period 1970-1977 are also presented.

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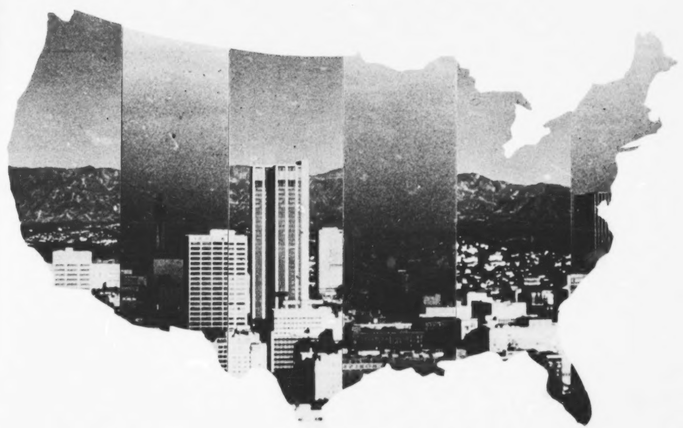

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NATIONAL AIR QUALITY, MONITORING
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1977

MONITORING AND DATA ANALYSIS DIVISION
MONITORING AND REPORTS BRANCH

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR, NOISE AND RADIATION
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711
DECEMBER 1978

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This report has been reviewed by the Monitoring and Data Analysis Division, Office of Air Quality Planning and Standards, Office of Air and Waste Management, Environmental Protection Agency, and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use. Copies are available free of charge to Federal employees, current contractors and grantees, and nonprofit organizations - as supplies permit - from the Office of Library Services, Environmental Protection Agency, Research Triangle Park, North Carolina 27711; or copies may be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20460.

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PREFACE

This is the seventh annual report of air pollution trends issued by the Monitoring and Data Analysis Division of the U. S. Environmental Protection Agency. The report is directed toward both the technical air pollution audience and the interested general public. The Division solicits comments on this report and welcomes suggestions on our trend techniques, interpretations, conclusions, and methods of presentation. Please forward any response to William F. Hunt, Jr., (MD-14) U. S. Environmental Protection Agency, Monitoring and Data Analysis Division, Research Triangle Park, N. C. 27711.

The Monitoring and Data Analysis Division would like to acknowledge William F. Hunt, Jr. and Neil H. Frank for the overall management, coordination, and direction given in assembling this report. Special mention should also be given to Carolyn Harvey and Phyllis Clark for their clerical support and Charles Keadle, Bobby Poole, Chuck Rodriquez, and Kim Chatham for the preparation of graphics and the printing of the report.

The following people are recognized for their contributions to each of the sections of the report as principal authors:

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Section 3 - Thomas C. Curran, Robert B. Faoro, and Neil H. Frank
Section 4 - Virginia Henderson, Jon B. Clark, and William F. Hunt, Jr.
Section 5 - Charles Mann
Section 6 - Neil H. Frank, Warren Frease, Ted Johnson, and Charles Mann

Also deserving special thanks for providing technical assistance are Mary Scott Ferebee, Charles Jones, Sherry Olson, Jerry Parrish, and H. Jefferson Smith.

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NATIONAL AIR QUALITY, MONITORING, AND EMISSIONS TRENDS REPORT, 1977

1. INTRODUCTION AND OVERVIEW

1.1 GENERAL OVERVIEW

Long term progress (1972-1977) can be seen in achieving compliance with the National Ambient Air Quality Standards (NAAQS) for total suspended particulate, sulfur dioxide, and carbon monoxide nationally. The long-term trend in oxidants for the nation as a whole has been stable, with a decreasing trend in California and a slightly increasing trend for those sites located outside California. Nitrogen dioxide trends are stable in California; nationally, however, nitrogen dioxide levels tend to be increasing based mostly on 3 to 4 years of data.

Air quality progress is measured by comparing the ambient air pollution levels with the appropriate primary and secondary NAAQS for each of the pollutants. Primary standards protect the public health, and secondary standards protect the public welfare as measured by effects of pollution on vegetation, materials, and visibility. The standards are further categorized for long- or short-term exposure. Long-term standards specify an annual mean that may not be exceeded; short-term standards specify upper limit values for 1-, 3-, 8-, or 24-hour averages that may not be exceeded more than once per year.

Data for analysis in this report were obtained primarily from the U.S. Environmental Protection Agency's National Aerometric Data Bank (NADB). These data are gathered primarily by State and local air pollution control agencies through their monitoring activities.

This is the seventh report in air pollution trends issued by the U.S. Environmental Protection Agency (EPA).[1-6] The report focuses on trends in population exposure for the nation, for the "Northeast Corridor" between Washington, D.C. and Boston, Massachusetts, and for two selected metropolitan areas: Cleveland and St. Louis. Changes in the population exposed to ozone were stressed in the Northeast Corridor Study, while changes in the population exposed to total suspended particulate levels above the NAAQS were examined for the Nation, Cleveland, and St. Louis.

The report introduces a new section, Status of Air Quality Monitoring, which documents the number of stations reporting air quality data by pollutant and measurement method for the year 1977. The intention of the section is to document the extent of monitoring in 1977 during the time of transition of the new national monitoring program as proposed in the Federal Register.[7] It should be noted that all references in this section and throughout the report to the NAAQS for photochemical oxidants (including ozone)refer to the present one-hour standard of 0.08 parts per million or 160 micrograms per cubic meter. EPA has indicated that it will revise this standard;[8] subsequent reports will reflect this change.

A unique feature of the report is the presentation of air pollution emission density maps for the nation by county for particulates, sulfur oxides, carbon monoxide, volatile organic compounds, and nitrogen oxides. These maps were prepared from originals developed using computer graphics. The

maps should be helpful for planning purposes and responding to the often asked question: "How does air quality vary across the United States?"

In this report we have introduced new trend statistics for the analysis of ozone, as well as the use of computer graphics for emission density maps and air quality isopleth maps in the Northeastern Corridor Study. We would like to invite our readers to comment on our trend techniques, interpretations, and conclusions and indicate to us what might be done to improve future reports.

The major findings of these investigations are as follows:

1. In 1977, 29% fewer people in the nation were exposed to annual mean total suspended particulate levels in excess of the primary standard than in 1972.

2. A major decrease was observed in the population exposed to high particulate levels in Greater Metropolitan Cleveland, where the proportion of the population exposed to particulate levels greater than the annual primary standard fell from 60% in 1972 to 27% in 1977. In St. Louis, the percentage of the exposed dropped from 69% to 62%.

3. The early 1970's saw dramatic decreases in ambient sulfur dioxide levels in the Nation's urbanized areas. The general pattern showed considerable initial improvement followed by fairly consistent, yet more stable progress. Only 2% of 2365 sulfur dioxide monitoring sites exceeded the 24-hour primary standard in 1977.

4. During the 1972-77 time period, 80% of 243 carbon monoxide trend sites showed improvement. The rate of improvement was fairly consistent with all geographical areas of the country showing progress. The national median rate of improvement for the 90th percentile of eight-hour values was approximately 6% per year.

5. The national ozone trend was basically stable over the 1972-77 period, with California showing a decreasing trend and the non-California sites slightly increasing. The O_3 trend was consistent with the national emission trend in volatile organic compounds (VOC). The reduction in VOC emissions from new cars has largely been offset by the 30% increase in motor vehicle miles travelled between 1970 and 1977 and increased industrial process emissions, thus resulting in both stable air quality and emission trends.

6. Photochemical oxidants (ozone) ranks as one of the most serious and pervasive air pollution problems in this country. In 1977, 86% of the ozone sites reporting to the NADB exceeded the NAAQS of 160 $\mu g/m^3$. It is estimated that 50% of the total population within the Northeast Corridor experienced summertime ozone violations of more than 202 hours in 1976 as compared to 123 hours in 1975 and 137 hours in 1977.

7. Nitrogen dioxide concentrations appear to be rising based on sites having at most 4 years of data. However, only 2% or 18 of the 933 sites monitoring nitrogen dioxide violated the annual primary standard in 1977; of the 18 sites, 15 were in California.

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2. **Monitoring and Air Quality Trends Report, 1972.** U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, N.C. Publication No. EPA-450/1-73-004. December 1973.

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6. **National Air Quality and Emission Trends Report, 1976.** U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, N.C. Publication No. EPA-450/1-77-002. December 1977.

7. **Federal Register,** Vol 43, August 7, 1978, p34930.

8. **Federal Register,** Vol 43, June 22, 1978, p26970.

2. POPULATION EXPOSURE TO AIR POLLUTION

In the 1975 and 1976 trends reports, population exposures to various air pollutants were examined for the Nation and for several metropolitan areas.[1,2] In this report, population exposures to total suspended particulate (TSP) are examined for the Nation and for the Metropolitan St. Louis and the Greater Cleveland Air Quality Control Regions (AQCR's). In addition, trends in population exposure to ozone are presented for the Northeast Corridor extending from Washington, D.C., to Boston.

Ideally, population exposure should be based on personal monitoring of air pollutants. The analyses presented here, however, have employed a simplified approach which involves the estimation of the air quality levels where the population lives. The population exposure analyses focus on changes in the numbers of people living in areas with pollutant levels above the primary (health-related) National Ambient Air Quality Standards (NAAQS's). These studies have been undertaken, in cooperation with EPA's Regional Offices, to measure the effectiveness of emission control plans in reducing air pollution to levels which protect public health. The changes in population exposures to high TSP levels were determined for the Nation and two metropolitan areas for the period 1972-1977; the changes in population exposure to high levels of ozone were determined for the Northeast corridor for the period 1975-1977. The time periods analyzed were selected according to the availability and completeness of air quality data.

Each level of analysis - national, regional, and metropolitan - used a different method of determining population exposure according to the spatial detail in the available monitoring data. For the national analysis of TSP, a simplified approach was used which separately examined data from metropolitan and nonmetropolitan areas. For the analysis of the two metropolitan areas, a more detailed approach was used in which population data were "gridded" into networks of population receptor points and then interfaced with corresponding air quality estimates from the local monitoring stations by spatial interpolation. For the regional analysis of ozone, data on total county population were interfaced with air quality estimated by spatial interpolation. Each approach yielded estimates of exposure to pollutants for the total population in the defined areas. In these analysis, population estimates were derived from 1970 census data and do not consider subsequent growth or shifts in population.

2.1 MAJOR DECREASES IN POPULATION EXPOSURE TO TSP LEVELS IN THE NATION

The number of people exposed to high TSP levels changed dramatically during the 1970's.[1,2] Nationally, 29% fewer people were exposed to annual mean TSP levels in excess of the NAAQS in 1977 than in 1972. This corresponded to a decrease of 8% in annual mean TSP concentrations nationwide (see Section 3.1). The long-term trend of decreases in population exposure to levels above the NAAQS occured before 1975; these levels were generally stable from 1975 through 1977 (Figure 2-1).

Separate data analyses were conducted for the counties in the metropolitan and nonmetropolitan areas of each AQCR. Based on the 1970 census, 188 million people lived in these areas where 2,700 monitors had collected sufficient historical data during the 1972-1977 period.

Most of the reduction in population exposed to high TSP levels is attributed to decreases in metropolitan areas, where the percent population affected dropped from 37% in 1972 to 27% in 1977. Exposure in nonmetropolitan areas, where TSP levels are generally lower, decreased from 16% in 1972 to 11% in 1977.

Regional patterns were seen in the 6-year changes in TSP levels and the corresponding population exposures (Figure 2-2). As shown previously, the largest improvements occurred in the Northeast, North Central, and the South.[2] Little change was seen in the Western States, where nontraditional sources of TSP, such as fugitive dust, continue to be major problems.

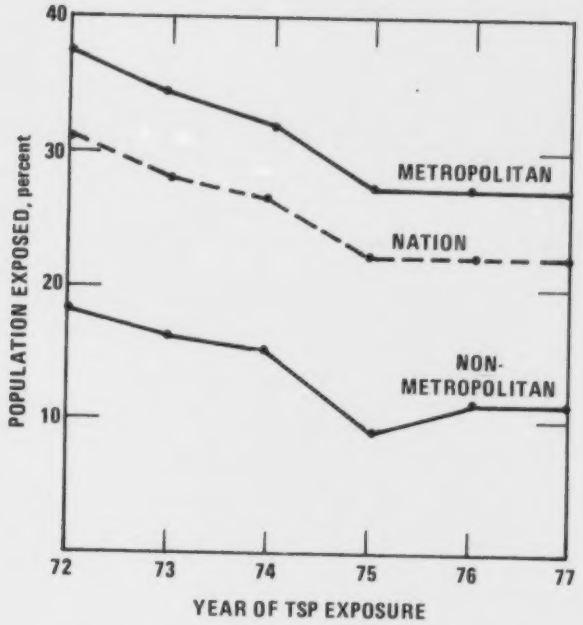

Figure 2-1. Population exposure to annual mean TSP in excess of NAAQS (75 $\mu g/m^3$).

2.2 MAJOR DECREASES IN POPULATION EXPOSURE TO TSP LEVELS IN CLEVELAND AND ST. LOUIS

Considerable progress towards meeting the NAAQS for TSP was seen in the Cleveland AQCR, and moderate progress was seen in the St. Louis Metropolitan area. Both large metropolitan areas have historically had serious air pollution problems. In Cleveland, the proportion of the population exposed to TSP levels greater than the annual primary standard decreased from 60% in 1972 to 27% in 1977. In St. Louis the percentage decreased from 69% to 62%. These improvements are attributed to the 1970 Federal Clean Air Act amendments and subsequent enforcement actions by State and local agencies against commercial, industrial, and municipal polluters.

2.2.1 The Cleveland AQCR

The changes in the number of people exposed to high TSP levels in the Cleveland AQCR were examined for 1972-77.[3] The analysis showed an overall reduction of 16% in average TSP levels. This improvement resulted in 54% fewer people being exposed annually to levels above the primary health-related standard of 75 $\mu g/m^3$.

The Cleveland AQCR is an eight-county region containing the metropolitan areas of Cleveland, Akron, and Canton (Figure 2-3). According to the 1970 Census, more than 80% of the 3.4 million people in the Cleveland AQCR reside in three urban centers: 1.96 million in Cleveland, 0.54 million in Akron, and 0.24 million in Canton. Figure 2-4 displays the population density for the AQCR. To interrelate air quality with demographic variables, census tracts were aggregated into 159 receptor points (Figure 2-5). Then the TSP air quality at each receptor point was estimated from TSP monitoring data by spatial interpolation.[4] Air quality data provided by 56 monitoring stations (Figure 2-6) were used for describing the trends in the spatial variation of TSP levels and for estimating the corresponding population exposure.

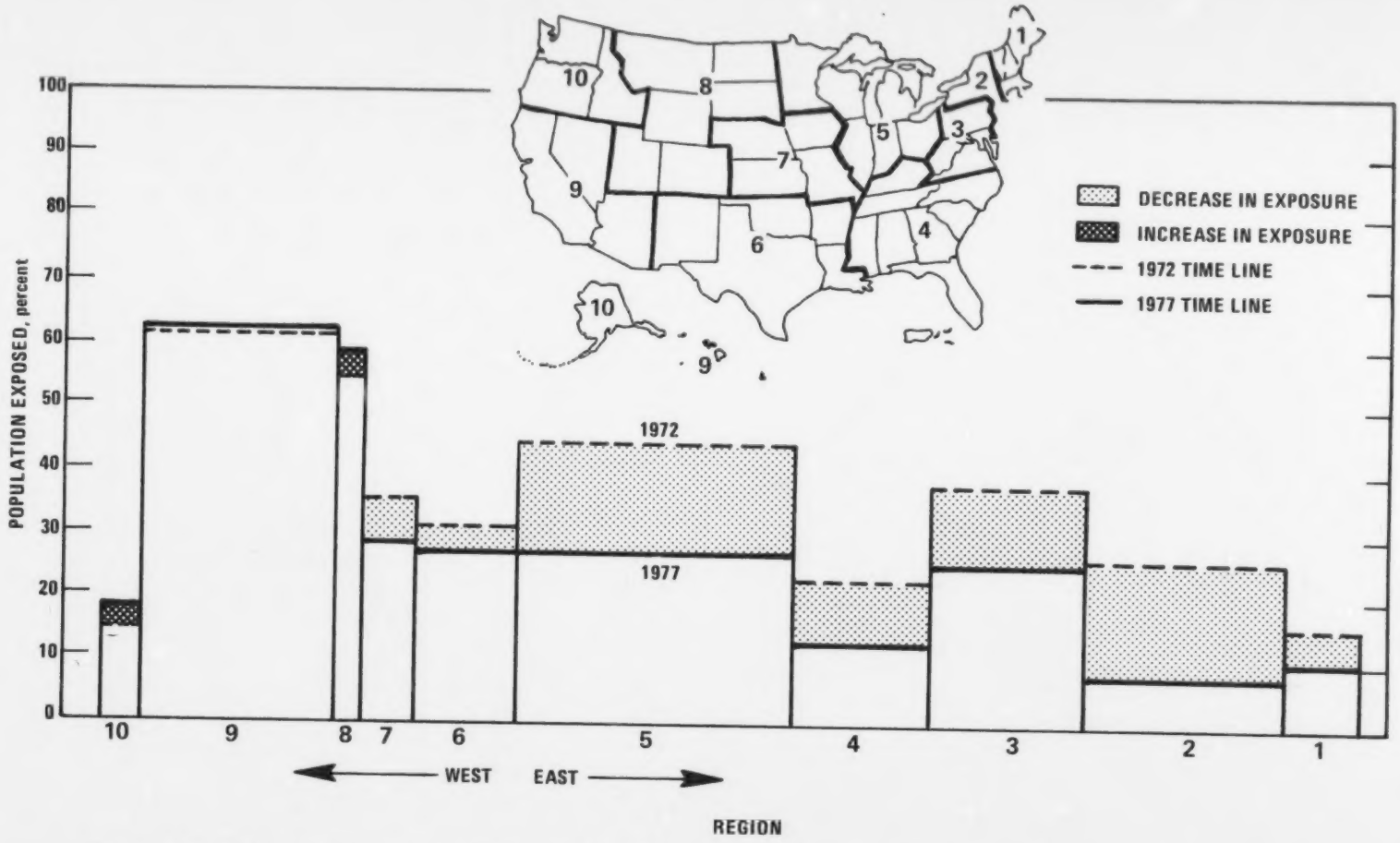

Figure 2-2. Regional changes in metropolitan population exposures to excess TSP levels, 1972-1977 (width of each regional column is proportional to its metropolitan population).

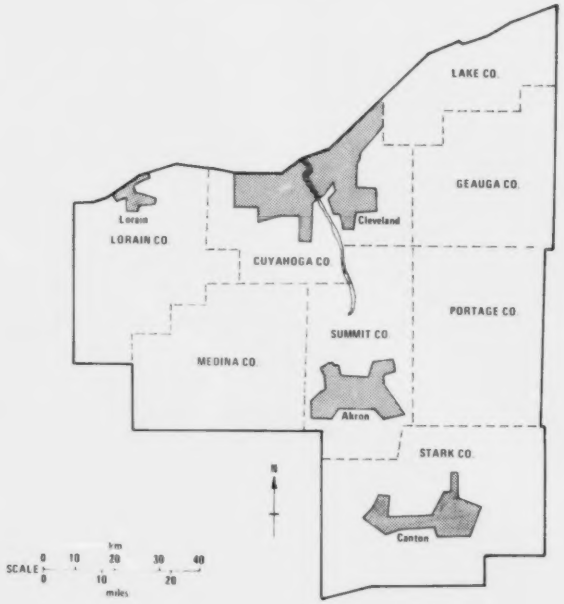

Figure 2-3. Greater Metropolitan Cleveland Air Quality Control Region study area.

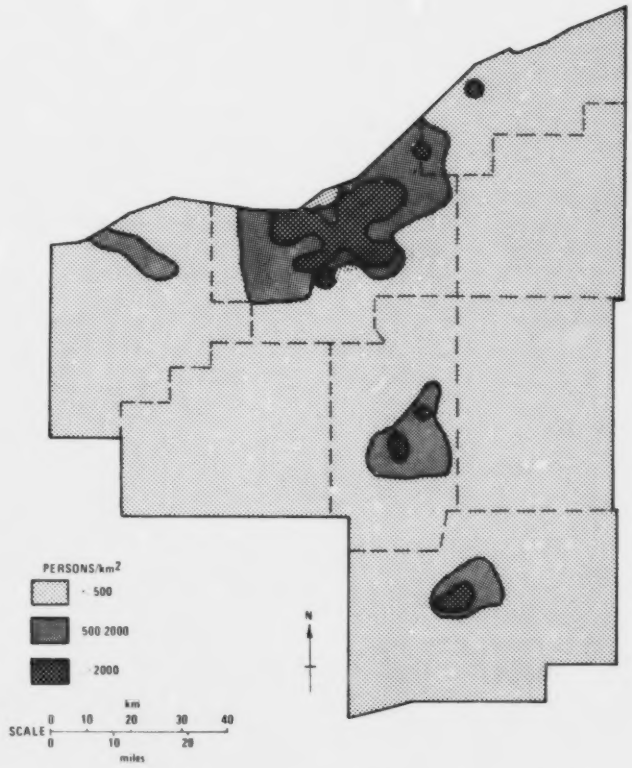

Figure 2-4. Population density pattern in Greater Metropolitan Cleveland in 1970.

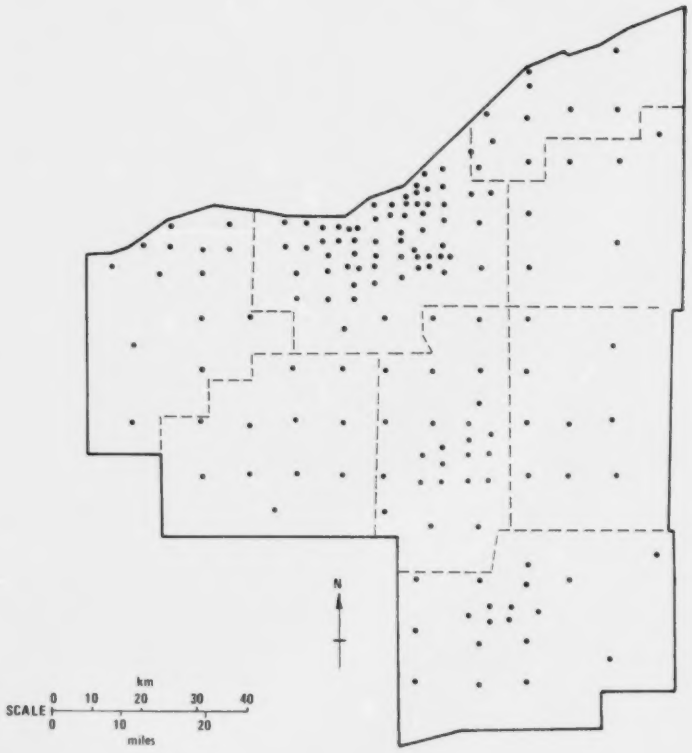

Figure 2-5. Receptor network in Greater Metropolitan Cleveland AQCR study area.

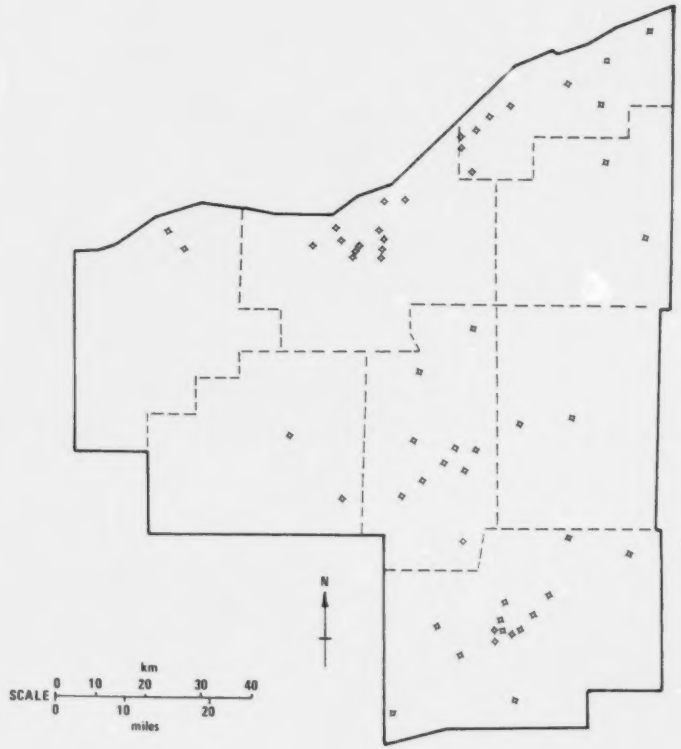

Figure 2-6. Location of total suspended particulate monitors in Greater Metropolitan Cleveland study area.

2.2.1.1 TSP Air Quality Patterns - Isopleths of average TSP levels during 1972 and 1977 are shown in Figure 2-7. In 1972, the highest TSP levels were experienced along the highly industrialized Cuyahoga Valley. Areas exceeding the NAAQS of 75 $\mu g/m^3$ included the three urban centers of Cleveland, Akron, and Canton. A steady regional reduction in TSP levels occurred between 1972 and 1977. Typical regional TSP exposures declined from 88 $\mu g/m^3$ in 1972 to 74 $\mu g/m^3$ in 1977. By 1977, areas exceeding 75 $\mu g/m^3$ were primarily limited to the core of the metropolitan Cleveland area.

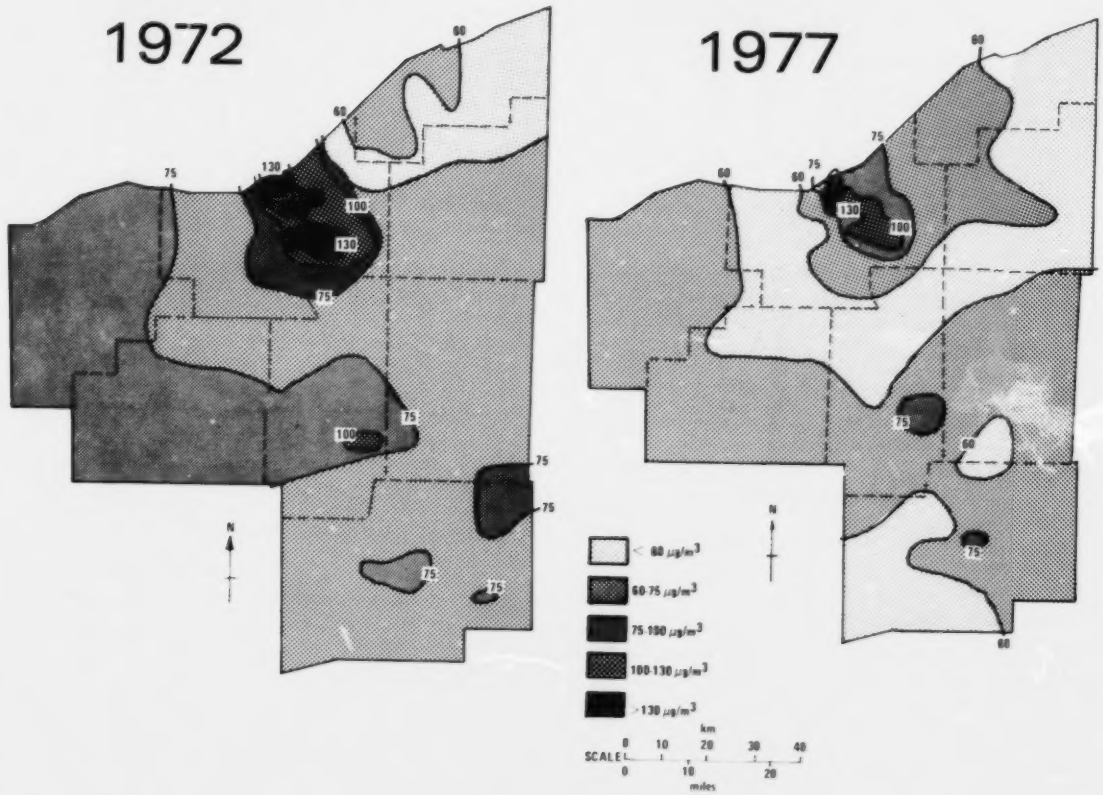

Figure 2-7. Annual mean total suspended particulate in Greater Metropolitan Cleveland Air Quality Control Region, 1972 versus 1977.

2.2.1.2 Changes in Population Exposure - Table 2-1 lists the number of people living in areas with average TSP greater than the annual primary standard as percentages of the total population and two susceptible population segments, children and the elderly. In 1972, 60% of the total population (or about 2 million) were living in areas where TSP levels exceeded the standard. This number decreased by more than half over the 6-year period; less than 1 million people were living in areas with excess TSP levels in 1977. The changes in the exposures of the child and elderly populations exhibited similar decreasing trends.

Table 2-1 NUMBER OF PEOPLE IN AREAS EXCEEDING THE ANNUAL PRIMARY STANDARD OF 75 $\mu g/m^3$ IN THE CLEVELAND AIR QUALITY CONTROL REGION, 1972-1977.

Population category	Total population	Percent of category population						Percent reduction between 1972 and 1977
		1972	1973	1974	1975	1976	1977	
Total Population	3,356,970	60	50	37	44	29	27	54
Children (17 years and under)	1,172,754	59	50	36	44	28	26	55
Elderly (65 years and over)	301,252	64	54	42	47	32	31	52

2.2.2 Metropolitan St. Louis

The changes in the numbers of people exposed to high TSP levels in the St. Louis metropolitan area were examined for 1972-77.[5] The analysis showed a reduction of 9% in average TSP levels between 1972 and 1977. This decrease resulted in 10% fewer people being exposed annually to TSP levels above the annual primary health-related standard of 75 $\mu g/m^3$. During the six-year period, TSP levels decreased more significantly during the first few years; this was largely offset, however, by increases in TSP levels since 1975 which were attributed to drought conditions.[2,6] The overall decrease was a continuation of the longer term reduction in St. Louis TSP levels reported elsewhere.[6]

The study area consisted of the central metropolitan portion of the St. Louis AQCR (Figure 2-8); it contains the city of St. Louis, the eastern portion of St. Louis County in Missouri, and the western portions of Madison and St. Clair Counties in Illinois. Based on the 1970 Census, the study area contained over 1.8 million people, which is 78% of the AQCR population. Figure 2-9 displays the population density for the study area and shows the highest density in the city of St. Louis.

The population data were aggregated from census tracts into 128 receptor points (Figure 2-10) to interrelate air quality data with demographic variables. Air quality at each of the receptors was estimated from TSP monitoring data by spatial interpolation. The air quality data were provided by 29 monitoring stations (Figure 2-11); each station produced valid data in at least 3 of the 6 years. These data were used to describe the trends in the spatial variation of TSP levels and to estimate the corresponding population exposure.

2.2.2.1 TSP Air Quality Patterns - Isopleths of average TSP levels during 1972 and 1977 are shown in Figure 2-12. In 1972, the City of St. Louis and the areas to the east and northeast had widespread violations of the primary NAAQS. TSP levels tended to be highest in the industrialized zones along the Mississippi River and the northeast of the City. By 1977, some improvement in overall TSP level was evident. Levels declined considerably within the city of St. Louis as well as within some outlying areas.

During the 6-year period, the largest improvement occurred between 1972 and 1973. Since then, TSP levels have been fairly stable, except for a moderate increase in 1976 which was partially attributed to dry conditions. Overall, typical TSP levels declined from 84 $\mu g/m^3$ in 1972 to 77 $\mu g/m^3$ in 1977 — a net decrease of 9%.

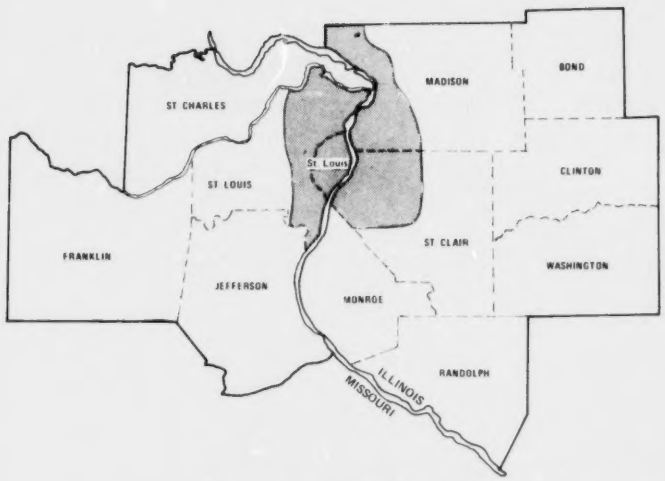

Figure 2-8. Metropolitan St. Louis study area.

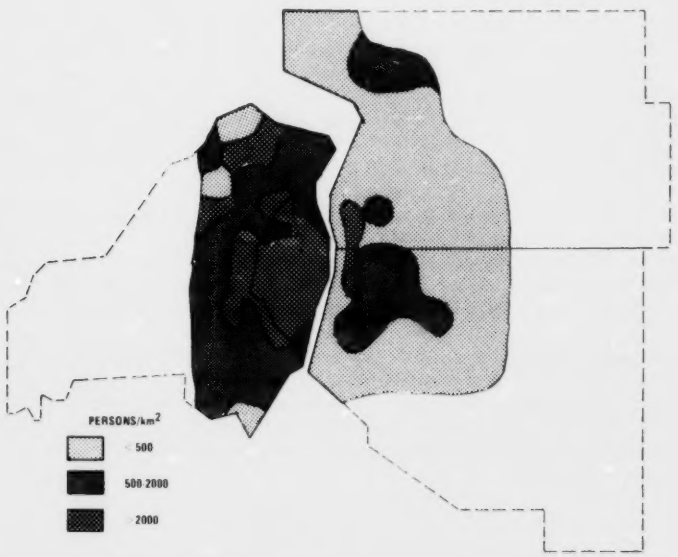

Figure 2-9. Population density in metropolitan St. Louis in 1970.

Figure 2-10. Receptor network in Metropolitan St. Louis study area.

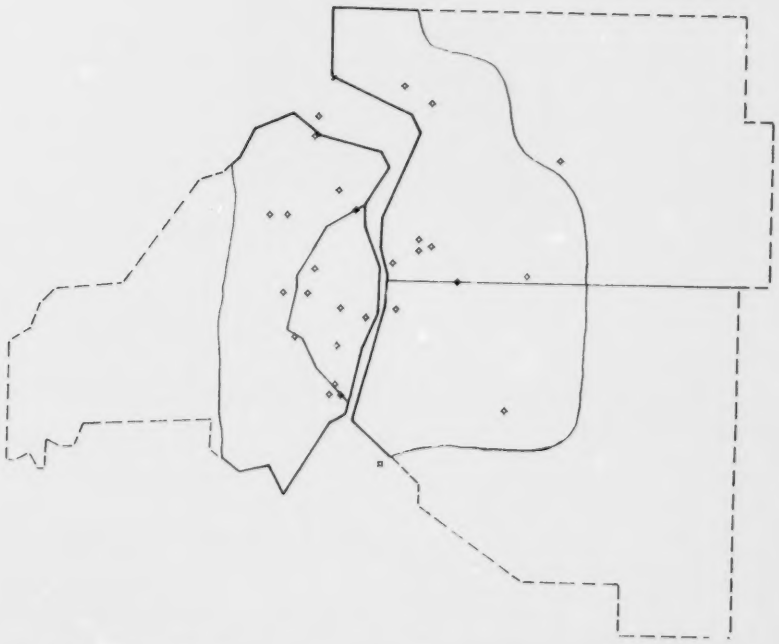

Figure 2-11. Location of total suspended particulate monitors in Metropolitan St. Louis study area.

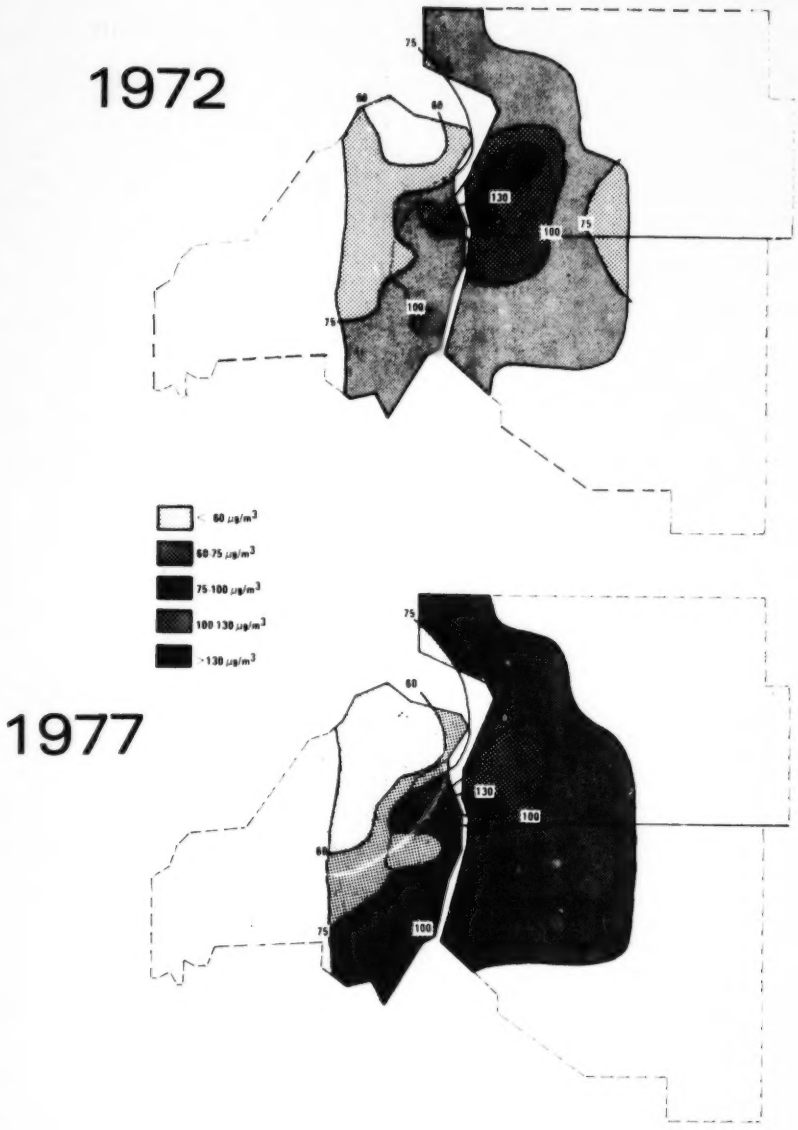

Figure 2-12. Annual mean total suspended particulates in Metropolitan St. Louis, 1972 versus 1977.

2.2.2.2 Changes in Population Exposure - Table 2-2 lists the number of people living in areas with average TSP levels greater than the NAAQS as percentages of the 1970 total population and of two susceptible subpopulations–children and the elderly. In 1972, 69% (or about 1.3 million) of the total population were living in areas where TSP levels exceeded the standard. The total number of people decreased by 10% over the 6-year period; 62% were living in areas with high TSP levels in 1977. The number of exposed elderly persons exhibited a slightly larger decline (-15%) due to the greater population density of elderly in the central city area.

Table 2-2 NUMBER OF PEOPLE IN AREAS EXCEEDING THE ANNUAL PRIMARY STANDARD OF 75 μ^3 IN METROPOLITAN ST. LOUIS, 1972-1977.

Population category	Total population	Percent of category population						Percent reduction between 1972 and 1977
		1972	1973	1974	1975	1976	1977	
Total Population	1,868,111	69	46	48	43	60	62	10
Children (12 years and under)	647,303	69	47	49	46	61	63	9
Elderly (65 years and over)	197,201	76	48	50	42	63	65	15

2.3 POPULATION EXPOSURE TO OZONE IN THE NORTHEAST CORRIDOR DURING THE SUMMER MONTHS OF 1975, 1976, and 1977

Trends in population exposure to ozone in the Northeast Corridor were investigated from 1975 through 1977. The Northeast Corridor (which extends from Washington, D.C. to Boston, Massachusetts) was chosen for analysis because of its dense population, its relatively high ozone levels, and its extensive monitoring networks. Exposure was expressed in terms of hours during which ozone levels exceeded the current NAAQS of 160 $\mu g/m^3$. The summer months of July, August, and September were used in the analysis because NAAQS exceedances occur most frequently and outdoor activity is usually greatest during these months. Furthermore, many monitoring stations in the Northeast Corridor record ozone data only during the summer months.

Figure 2-13 shows the study area and the locations of the 107 ozone monitors supplying ozone data for the analysis. The study area boundary was determined by the distribution of ozone monitors, topographical features, and population density. In 1970, this area accounted for 19% of the total U.S. population.

The air quality data produced by the ozone monitoring networks were examined in combination with 1970 population data to determine population exposure. The population centroid in each county was used to identify the average residential location. The estimated number of hours exceeding the NAAQS at each centroid was extrapolated from ozone data recorded at the nearest three monitoring stations using a spatial interpolation procedure.[4]

2.3.1 Ozone Air Quality Patterns and Estimated Exposure

The estimated number of hours exceeding the NAAQS for each county in the Northeast Corridor during July, August, and September of 1975, 1976, and 1977 is shown in Figure 2-14. Yearly, there were wide variations throughout the corridor in the number of hourly ozone exceedances. The summer of 1976 had the highest number throughout most of the study area. An estimated 50% of the total population experienced ozone exceedance of more than 202 hours in 1976, compared to 123

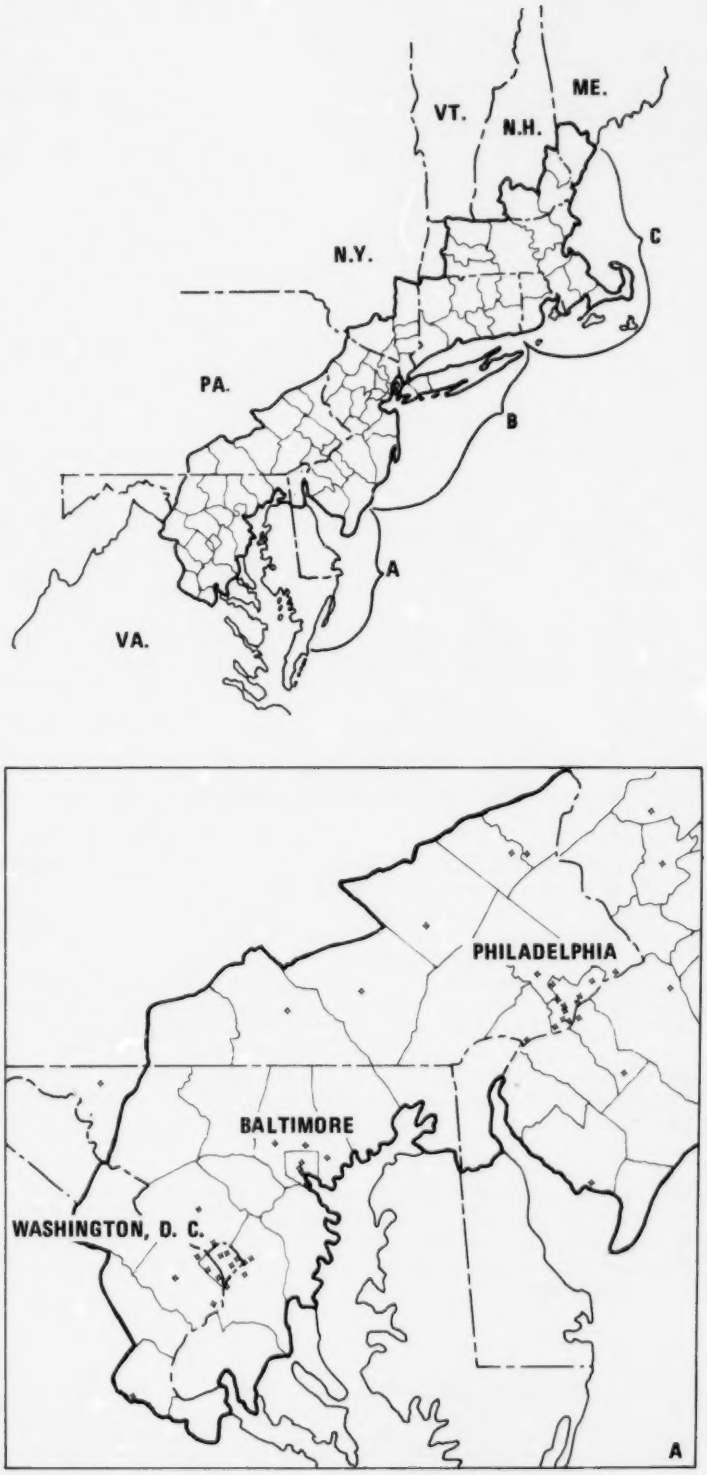

Figure 2-13. Northeast Corridor Study Area and location of ozone monitoring sites.

Figure 2-13 (continued). Northeast Corridor Study Area and location of ozone monitoring sites.

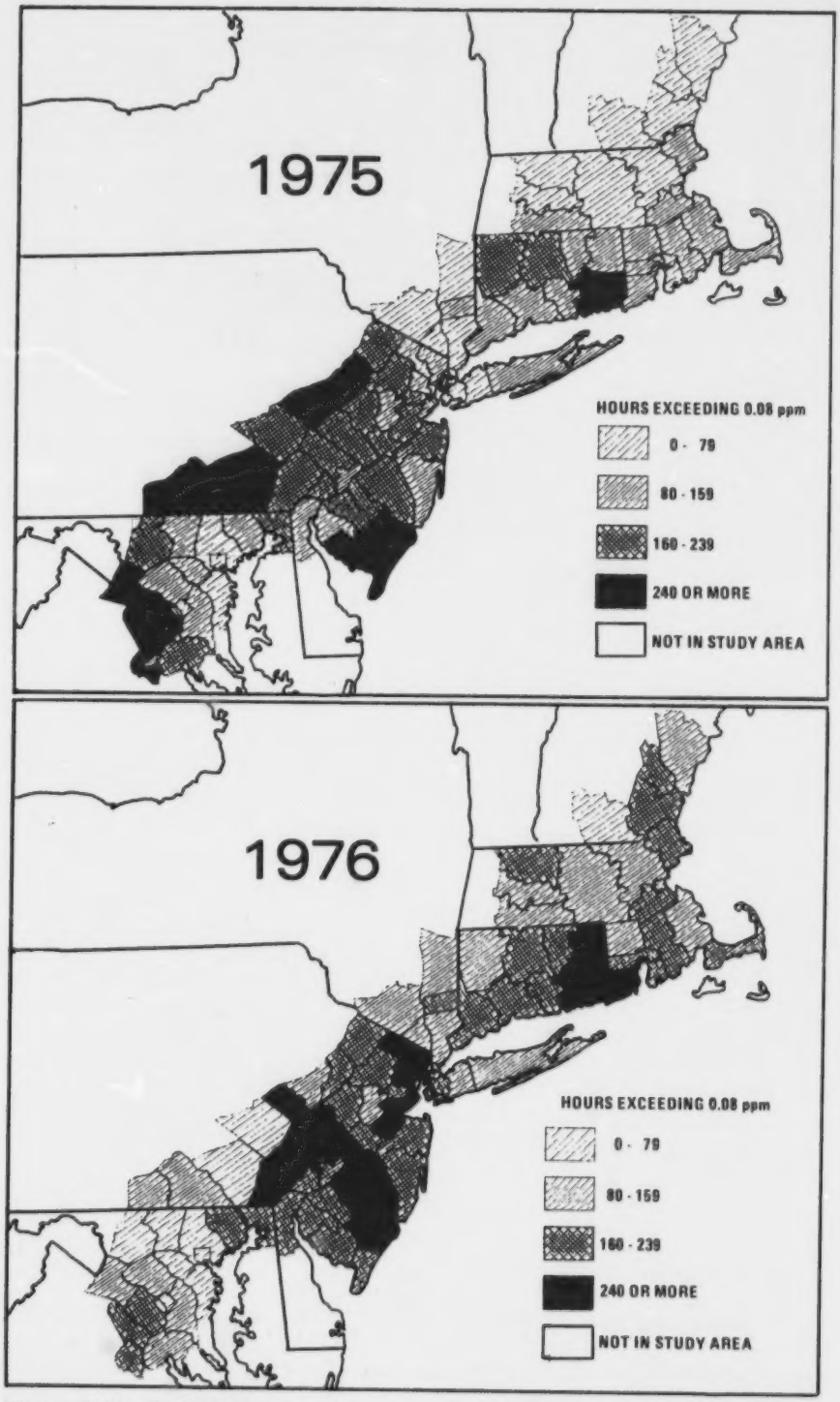

Figure 2-14 Estimated hours ozone exceeded 0.08 ppm during July, August, and September of 1975, 1976, and 1977 in the Northeast Corridor Study Area.

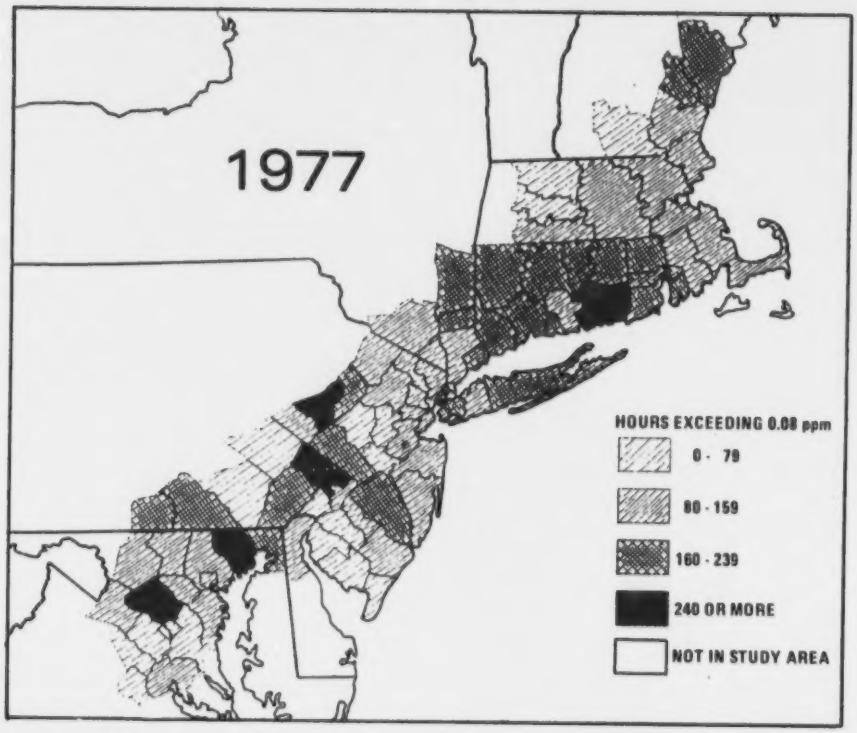

Figure 2-14 (continued). Estimated hours ozone exceeded 0.08 ppm during July, August, and September of 1975, 1976, and 1977 in the Northeast Corridor Study Area.

hours in 1975 and 137 hours in 1977 (see Figure 2-15). During the 3-year period, parts of Maryland, New York, and Massachusetts displayed the fewest exceedances, while Pennsylvania, New Jersey, and Connecticut had the highest number of exceedances.

The 3-year trend in exceedances was variable within the corridor. The western parts of the region as well as much of New Jersey and Pennsylvania showed overall improvement. Eastern Pennsylvania and parts of New Jersey, in fact, had their fewest number of exceedances in 1977. Contrary to this, air quality in the New England area as well as central Maryland worsened during the 3-year period. The exceedances increased in New England in 1976 and the high ozone levels were maintained during 1977; the increase in Maryland occurred in 1977.

2.3.2 Interpretation of Ozone Trends

Because of the year-to-year variability that is inherent in air quality data, the observed variations in ozone levels in the summers of 1975, 1976, and 1977 are not necessarily indicative of an expected long-term trend. Monitoring data show that the higher number of exceedances during the summer of 1976 resulted mainly from higher than normal ozone levels in August and September.[7] These variations in ozone levels may have resulted from short-term fluctuations in meteorological conditions or precursor emissions.

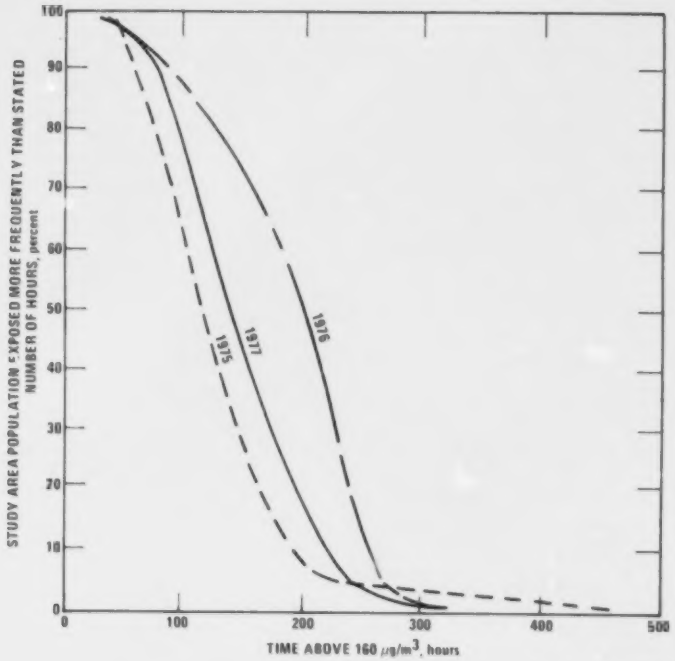

Figure 2-15. Change in population exposure to oxidants in Northeast Corridor during summer months, 1975 - 1977.

One of the meteorological factors most often associated with high ozone levels is high solar radiation. Incoming solar radiation data were reported at two stations in the study area — Washington and Boston — but only for 1975 and 1976. Analysis of these data showed that August and September in 1976 had higher solar radiation levels than the same months in 1975. Data for all three years were available for two meteorological factors associated with insolation — average cloud cover and morning precipitation. Figure 2-16 summarizes data from 7 representative weather stations in the Northeast Corridor. The lower average values for both cloud cover and morning precipitation for August and September 1976 show that greater insolation was available in these months than in the corresponding months of 1975 and 1977. Values of other meteorological factors related to ozone formation — maximum daily temperature, wind speed, cold front passages, and mixing height — either were not indicative of elevated ozone levels in the Northeast Corridor or were not significantly different in 1976 compared to the other two years.

The major sources of ozone precursors are automobiles. Emissions in July and August from automobiles in the Northeast Corridor showed a general decrease from 1975 to 1977, while emissions in September were slightly higher in 1976 than the other two years. However, this anomaly probably had minimal impact on the number of exceedances reported during the summer of 1976. The higher ozone levels in 1976 are more likely linked to the higher solar insolation of that year.

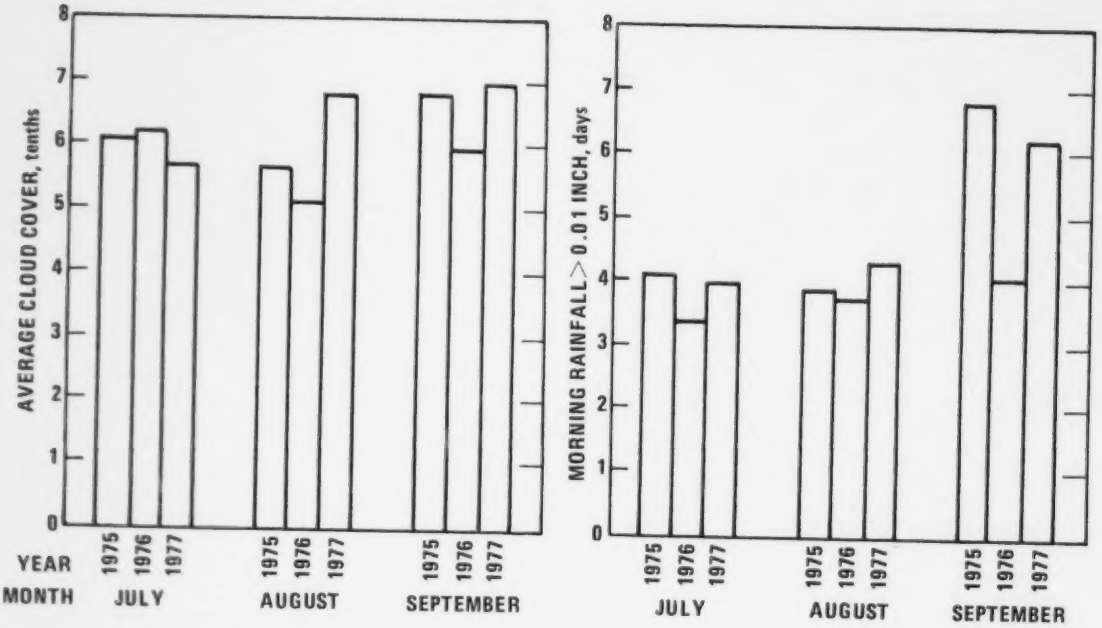

Figure 2-16. Means of meteorological data from seven weather stations in the Northeast Corridor for summer months of 1975, 1976, and 1977.

2.4 REFERENCES

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2. **National Air Quality and Emissions Trends Report, 1976.** U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, N.C. Publication No. EPA-450/1-77-002. December 1977.

3. Horie, Y. Interim Report on Trends in Particulate Air Pollution and Population Exposure to TSP in the Cleveland AQCR. Technology Service Corporation, Santa Monica, California. Prepared for the Monitoring and Data Analysis Division, U.S. Environmental Protections Agency. May 1978.

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5. Horie, Y. Interim Report on Trends in Particulate Air Pollution and Population Exposure to TSP in the St. Louis AQCR. Technology Service Corporation, Santa Monica, California. Prepared for the Monitoring and Data Analysis Division, U.S. Environmental Protection Agency. July 1978.

6. Shuster, S. L. Air Pollution over Greater St. Louis, U.S. Environmental Protection Agency, Region No. 7, EPA-907/9-78-003. December 1978.

7. Johnson, Ted, R. Rehm, and J. Capel. Population Exposure to Ozone in the Northeast Corridor during the Summers of 1975, 1976, and 1977 (in preparation). PEDCo Environmental Inc., Durham, N.C.

8. Slater, H. and T. Johnson. A Study of Ozone Levels in Relation to Precursor Emissions and Weather Parameters in the Northeast Corridor during the Summers of 1975, 1976, and 1977 (in preparation). PEDCo Environmental Inc., Durham, N.C.

3. NATIONAL AND REGIONAL TRENDS IN CRITERIA POLLUTANTS

Trends in ambient levels of total suspended particulate (TSP), sulfur dioxide (SO_2), carbon monoxide (NO_2), oxidants/ozone (O_3), and nitrogen dioxide (NO_2) are reported in this section. Each of these criteria pollutants is discussed individually; the extent of the analysis varies according to the amount of available historical data. The major emphasis is upon national trends and trends over broad geographical regions. As in previous reports,[1,6] California is emphasized in the subsections dealing with the automotive-related pollutants -CO, O_3, and NO_2 - because of extensive historical monitoring of these pollutants.

3.I TRENDS IN TOTAL SUSPENDED PARTICULATE

Total Suspended Particulate (TSP) levels throughout the nation have improved during the 1970's. These trends have been discussed in previous reports.[1-6] This section examines long-term TSP trends from 1972 through 1977 and the short-term changes from 1976 to 1977. The general trend shows long-term improvement with a gradual leveling off in the past few years.

Data for describing these trends were obtained from EPA's National Aerometric Data Bank, which stores air quality data submitted by State and local agencies and by federal monitoring programs. To ensure seasonal balance, trend sites were selected only if they had four consecutive quarters of TSP data in both the 1972-74 and the 1975-77 time periods. Accordingly, 2,707 sites that met this selection criterion were included in the analysis. Over 70% of these sites had at least 4 years of data and over 90% had at least 3 years.

Throughout this section, as in previous reports,[5,6] trends are depicted using a modified box-plot[7] to display simultaneously several features of the data. Figure 3-1 illustrates the use of this technique in presenting the composite average, the median, and selected percentiles corresponding to the lower and higher concentration levels.

3.1.1 Long-Term TSP Trends: 1972-77

Figure 3-2 is a box-plot presentation of national trends in geometric mean TSP levels from 1972 to 1977. During this period, the nationwide average decreased by 8%, an improvement of almost 2% per year. While all parameters show improvement, the decrease in TSP levels is most pronounced in the 90th percentile values of the box-plots.

Figure 3-3 summarizes TSP trends for each of the 10 EPA Regions. The overall trend in improvement from 1972 through 1975 was followed by a reversal in some regions in 1976; this reversal is discussed in more detail in the following section on short-term changes.

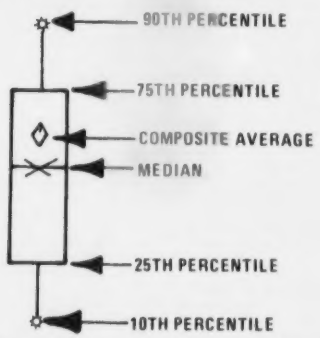


Figure 3-1. Sample illustration of plotting conventions for box plots.

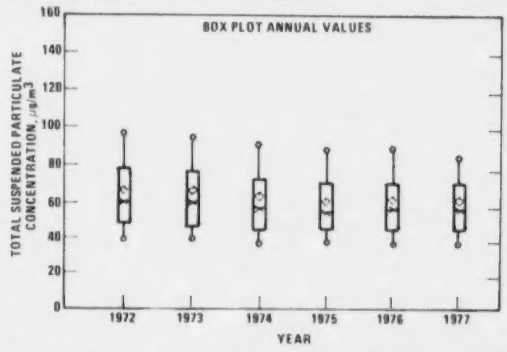


Figure 3-2. Nationwide trends in annual mean total suspended particulate concentrations from 1972 to 1977 at 2,707 sampling sites.

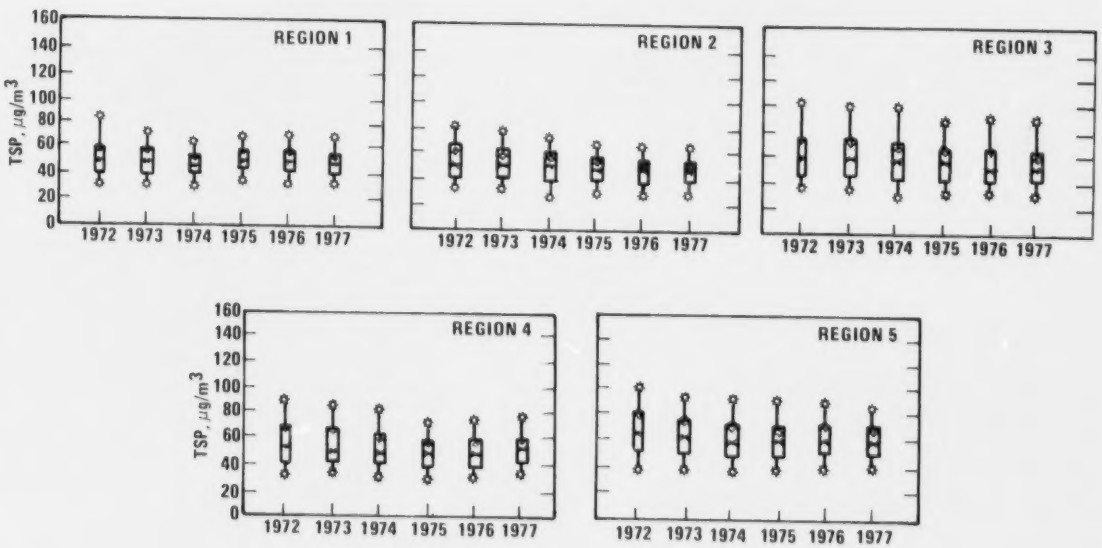
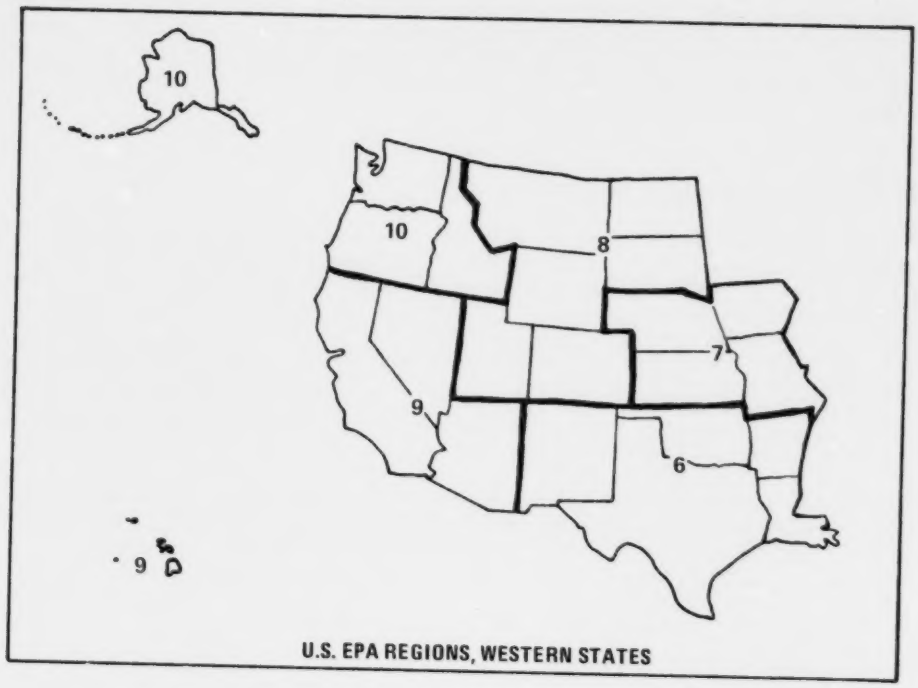


Figure 3-3. Regional trends of annual mean total suspended particulate concentrations, 1972 - 1977.



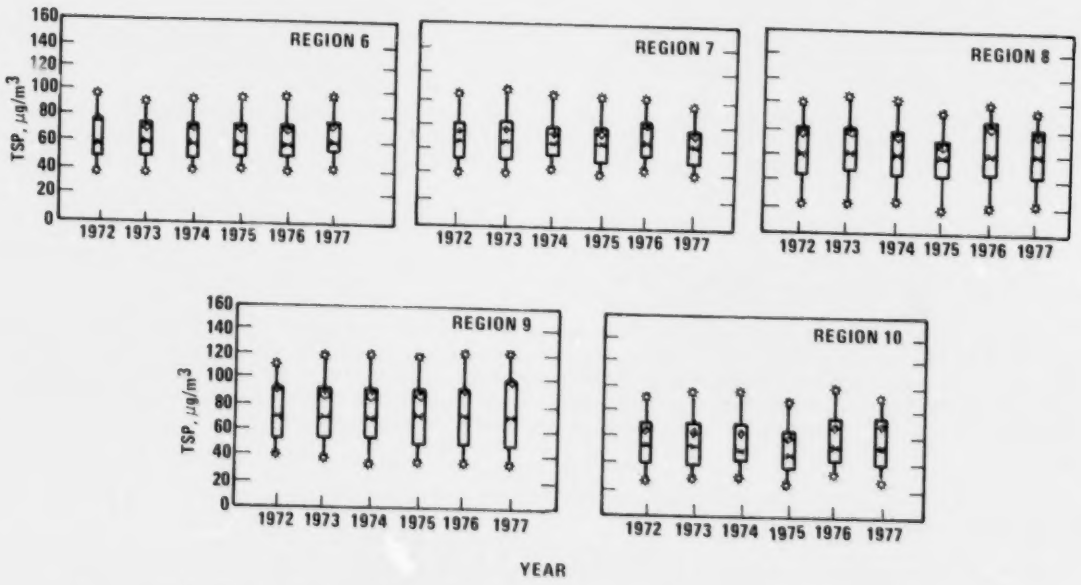


Figure 3-3 (continued). Regional trends of annual mean total suspended particulate concentrations, 1972 - 1977.

Despite the short-term reversal in 1976, 60% of the sites showed long-term improvement from 1972-1977. For those sites with TSP concentrations exceeding the annual standard, 77% showed long-term improvement. Approximately 25% of the sites reported their lowest annual values in 1977.

Although there has been a nationwide decrease in levels of total suspended particulate matter, there is evidence that levels of some types of particulates may be increasing. This is indicated by increasing trends in secondary particulates, such as sulfates[8] and deterioration of visibility in the Southwest and nonurban areas of the East.[9,10] The patterns are consistent with growth of emission sources outside of large metropolitan areas.

3.1.2 Short-Term TSP Changes: 1976-77

The short-term increase in TSP levels in 1976 was discussed in detail in last year's report.[6] Many areas experienced unusually dry weather in 1976; the resulting wind-blown dust may have contributed to elevated TSP levels. On February 24, 1977, the extremely dry soil conditions in the Central Plains and a strong frontal system resulted in dust being stirred up and transported east. The resulting high TSP levels measured throughout the Southeast were discussed previously.[6] Figure 3-4 shows peak value TSP levels in Region VI (Central Plains) by quarter from 1972 through 1977. The dramatic increase in the first quarter of 1977 is obvious from this graph. Monitoring sites throughout Texas, Oklahoma, and Arkansas reported high TSP levels during this February dust-storm. Several sites recorded daily values in excess of 1000 $\mu g/m^3$, a single value of this magnitude would increase the annual geometric mean at a site by 10%.

The short-term increases associated with unusually dry conditions had relatively little effect on the percentage of sites nationwide exceeding the TSP standard. In fact, those sites exceeding the annual mean standard continue to show improvement by a two to one margin.

3.2 TRENDS IN SULFUR DIOXIDE

Sulfur dioxide (SO_2) levels in urban areas throughout the Nation have gradually improved since 1970.[1-6] The 1972-1977 trends show dramatic initial improvement followed by fairly consistent continuing improvement. In most urban areas, this is consistent with the switch in emphasis from attainment of standards to maintenance of air quality; that is, the initial effort of reducing pollution to acceptable levels has been followed by efforts to maintain air quality at these lower levels.

Sites providing data for these analyses were selected from EPA's National Aerometric Data Bank. As with TSP, trend sites for the 1972-1977 time period were selected to ensure the historical completeness and seasonal balance of data. For SO_2, 1,233 sites had sufficient data to qualify as trend sites.

3.2.1 Long-Term SO_2 Trends: 1972-77

Figure 3-5 illustrates nationwide trends in annual mean sulfur dioxide levels from 1972 through 1977. The graph shows that sulfur dioxide levels continued to improve in the middle 1970's although the rate of improvement was much less pronounced than in 1970. From 1972 through 1977, the national average SO_2 level dropped 17%, an annual improvement rate of 4% per year. As would be expected, the majority of sites showed improvement during this period.

3.2.2 Short-Term SO_2 Changes: 1976-77

Short-term changes in sulfur dioxide levels between 1976 and 1977 were mixed, with no predominant trend. Most urban area SO_2 monitors reported levels well below the annual standard. High SO_2 levels are primarily associated with specific point sources.

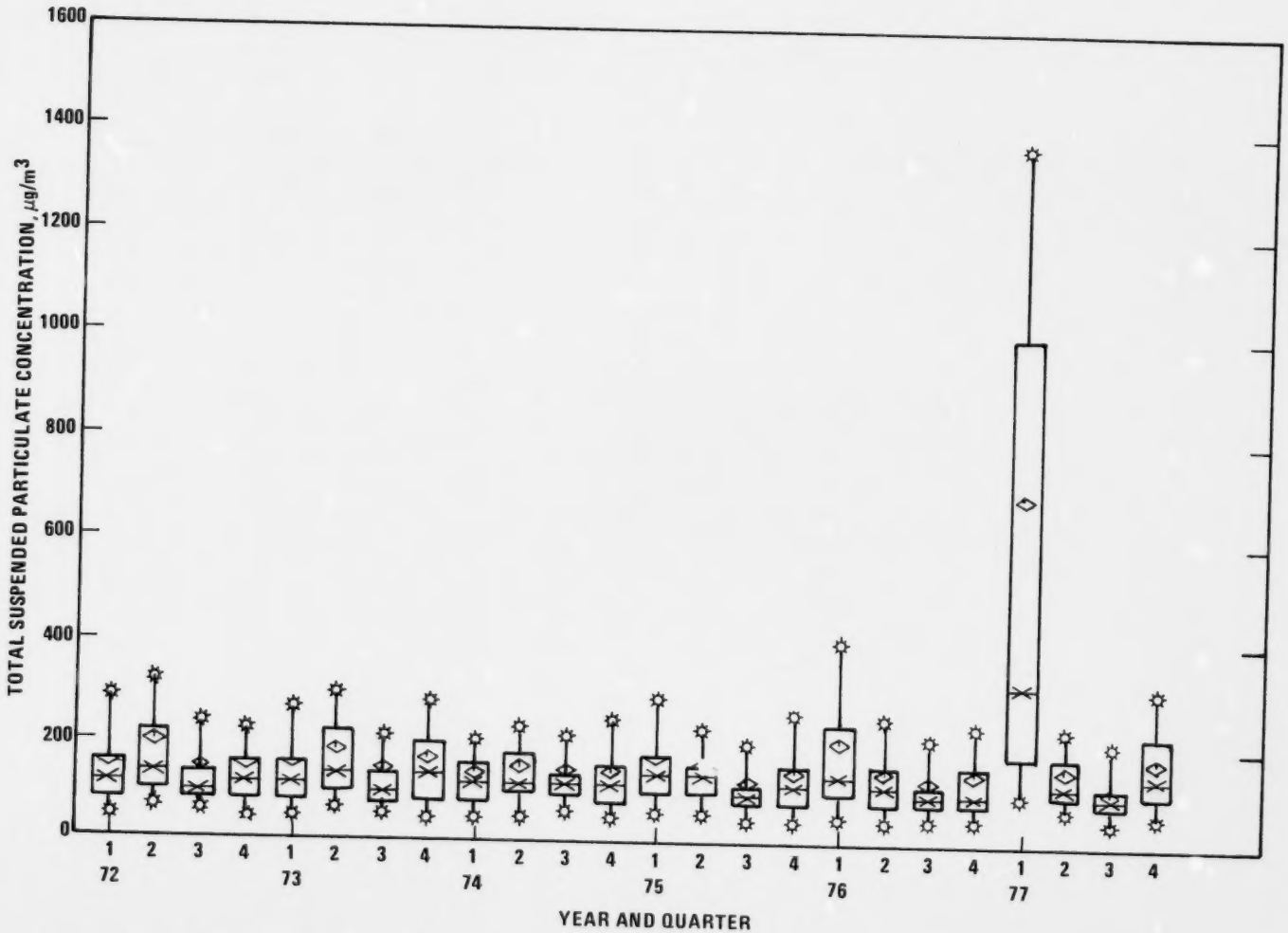


Figure 3-4. Quarterly total suspended particulate maximum values in Region VI from 1972 to 1977 illustrating the effect of the 1977 dust storm.

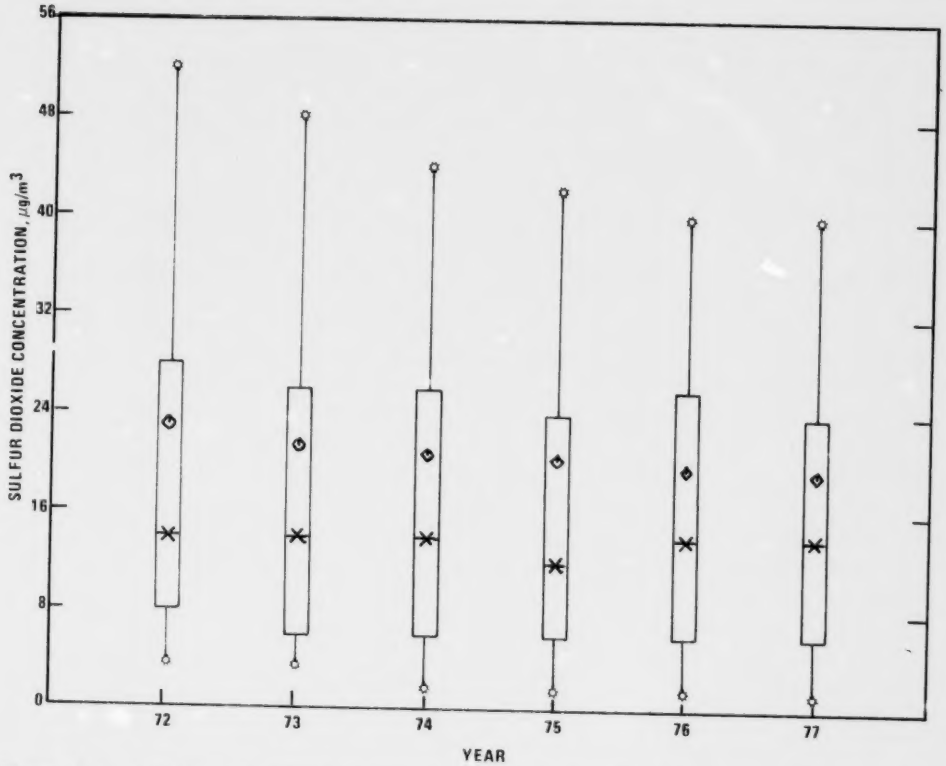


Figure 3-5. Nationwide trends in annual average sulfur dioxide concentrations from from 1972 to 1977 at 1,233 sampling sites.

3.3 TRENDS IN CARBON MONOXIDE

Ambient levels of carbon monoxide (CO) generally improved from 1972 to 1977. The nationwide data base over the years for CO has not been as extensive as those for TSP and SO_2;[1-6] however, there was a 20% increase in the number of sites with sufficient data for trends analysis due to the expansion of State and local monitoring programs. Data for CO trend analysis were obtained from EPA's National Aerometric Data Bank. All sites having at least 4,000 annual values during both 1972-1974 and 1975-1977 were designated as trend sites. For carbon monoxide, 243 sites met this selection criterion, and more than 80% of these sites had at least 4 years of data.

During the 1972-77 period, 80% of the selected CO sites showed long-term improvement and this trend was fairly consistent for all 10 EPA Regions. The median rate of improvement for the 90th percentile of 8-hour values was approximately 6% per year. From 1976 to 1977, 70% of the 243 sites improved. Consistent with this downward trend, almost one-third of these sites reported their lowest values in 1977.

Emission changes and meteorology can influence CO levels. An analysis of CO levels in New Jersey from 1971 to 1977 revealed that the 1974 gasoline shortage with its changing driving habits had a strong effect during the winter of 1973-74, but the effect gradually diminished with time.[11] All sites showed significant improvement in ambient CO levels; the results were valid even after accounting for the effects of meteorology. The continuing improvement at the CO sites in this study was attributed to both State and Federal CO emission reduction programs.

In discussing the relationship between ambient CO levels and CO emissions, it is important to clarify certain components involved in estimating CO emissions. Two key factors are the vehicle miles travelled (VMT) and the emissions per VMT. In its simplest form, total CO emissions may be viewed

as merely the product of emissions per mile multiplied by the number of miles travelled. As indicated in Section 5, total CO emissions in 1976-77 were higher than in 1974-75. During this time, the emissions per VMT actually decreased due to emission controls, but this was more than offset by an even greater increase in VMT. The net effect was an overall increase in total CO emissions. Translating these emission components in terms of ambient CO levels, it would be reasonable to expect improvement at downtown locations that are saturated with traffic because the emissions per mile reductions would outweight any increase in VMT. On the other hand, growth areas could record increases in ambient CO levels because increases in VMT offset the reduction in emissions per VMT.

3.4 TRENDS IN PHOTOCHEMICAL OXIDANTS

Air quality trends in photochemical oxidant air pollution, commonly expressed as ozone (O_3), were studied for the 1972-77 period. California showed mixed trends. Areas outside of California had approximately 33% more sites with increasing O_3 trends. The incomplete data base makes it difficult to determine the true significance of these variations; few of the trends were statistically significant. Higher O_3 levels in 1977 than in 1976 could account for some of the upward patterns, particularly for sites with only 3 or 4 years of data. Continuous O_3 data were available in Los Angeles from the early sixties to 1977; these data indicate that substantial long-term improvement has been made in an area where O_3 problems are known to be severe.[5,6] However, in other parts of the country, monitoring for photochemical oxidants did not begin until 1973-74, so data were limited.[1-6] These data base limitations were compounded at some sites by the shift during various years from a general method of measuring photochemical oxidants to a method specific to O_3.

3.4.1 Trend Statistics

As in the previous report,[5] trends are examined in terms of the annual 90th percentile of hourly values. This report also presents the 90th percentile of second and third quarterly data collected from April through September. The latter statistic was chosen because ozone is a seasonal pollutant with its highest values occurring during these months. Furthermore, numerous State and local agencies have elected to monitor only during this peak pollutant season. Both annual and quarterly 90th percentiles are more stable indicators than the peak highest or second highest values and yet still characterize the highest ozone levels.

A site was included in the analysis of annual data if it had at least 4000 annual observations in both the 1972-75 and 1976-77 time periods. Nationally, 231 sites in 35 states met this criterion. All sites had at least 3 years of data in the 1972-77 period. For the analysis of quarterly data, a site was selected if it had at least 1000 observations in a second and third quarter in both the 1972-75 and 1976-77 periods. Accordingly, a collection of 219 sites with more complete data in the peak ozone season were selected.

3.4.2 California and Non-California Trends: 1972-77

Figure 3-6 presents nationwide trends in ozone for ambient levels observed during the second and third calendar quarters. They are contrasted with corresponding California and non-California trends.

Overall, the national trend is essentially flat over the 6-year period. It is consistent with the national emission trend in volatile organic compounds (VOC) which also shows a slight dip in 1975, a year with a mild economic recession (Figure 3-6). The reduction in VOC emissions from new cars has largely been offset by the 30% increase in motor vehicle miles travelled between 1972 and 1977 and increased industrial process emissions. As a result, emission and air quality levels have both remained stable.

The stable national trend is a composite of different trends. In general, California sites display a downward trend, while non-California sites show a slight upward trend. These results are also reflected in the analysis of the annual 90th percentile levels.

Figure 3-7 shows the percentages of downward and upward changes at California and non-California sites based on annual 90th percentile ozone levels. Most of the sites (82% in California and 68% elsewhere) fall in the "stable" interval between −9% and +9% over the 1972-1977 time period. The California sites showed both increasing and decreasing patterns while the other sites show a greater tendency for increases. Of the non-California sites, 28% had an annual percent rate of change of ± 10% or more.

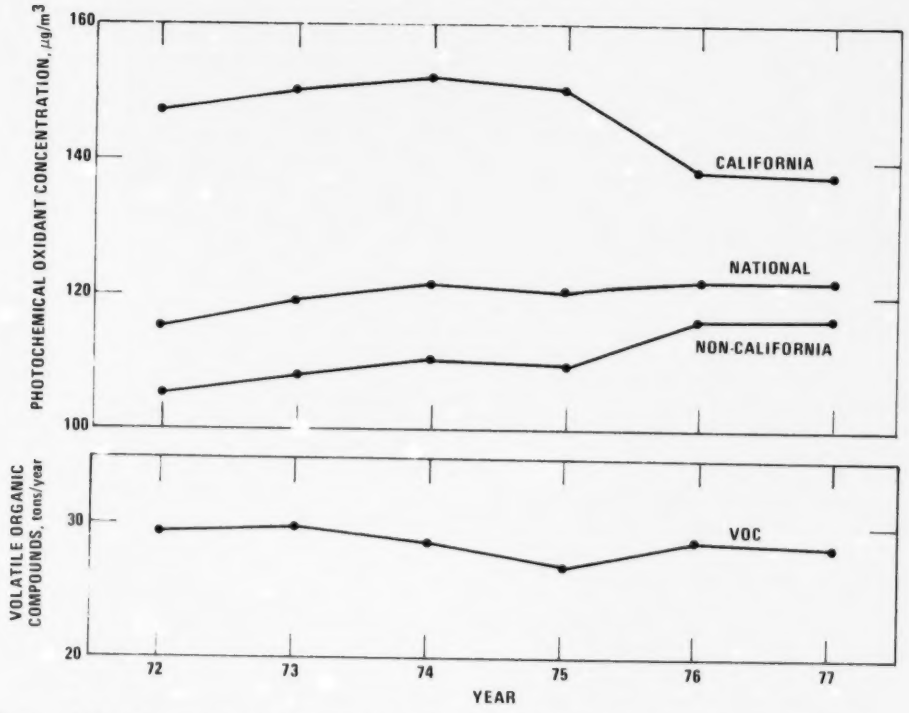


Figure 3-6. Comparison of National, California and non-California photochemical oxidant trends in the 90th percentile of the hourly second and third quarter values with national emission trends in volatile organic compounds, 1972 - 1977.

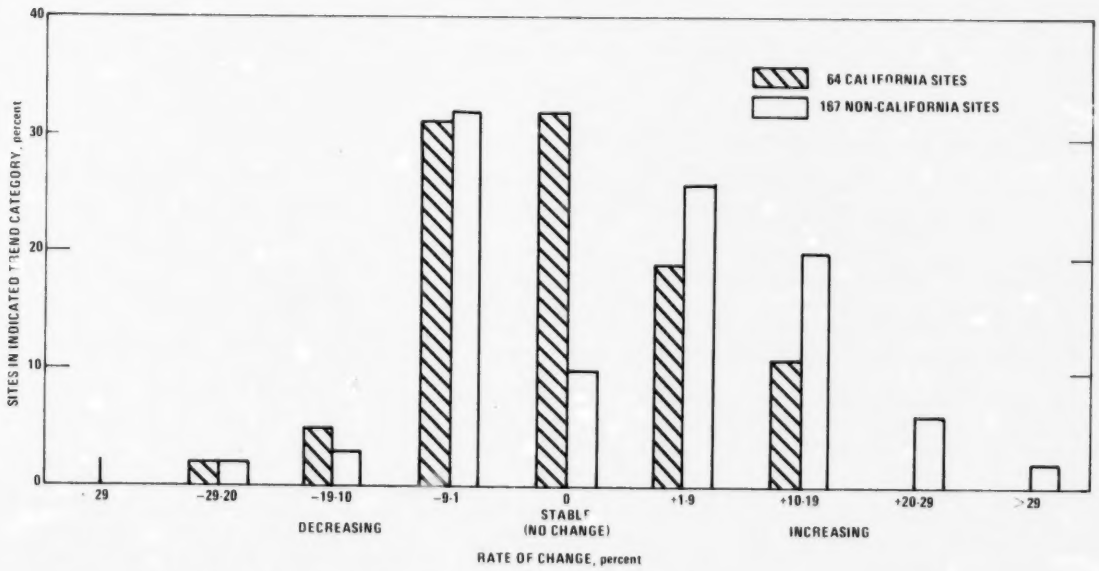


Figure 3-7. Distribution of yearly percent rate of change in annual ozone concentrations, 1972 - 1977.

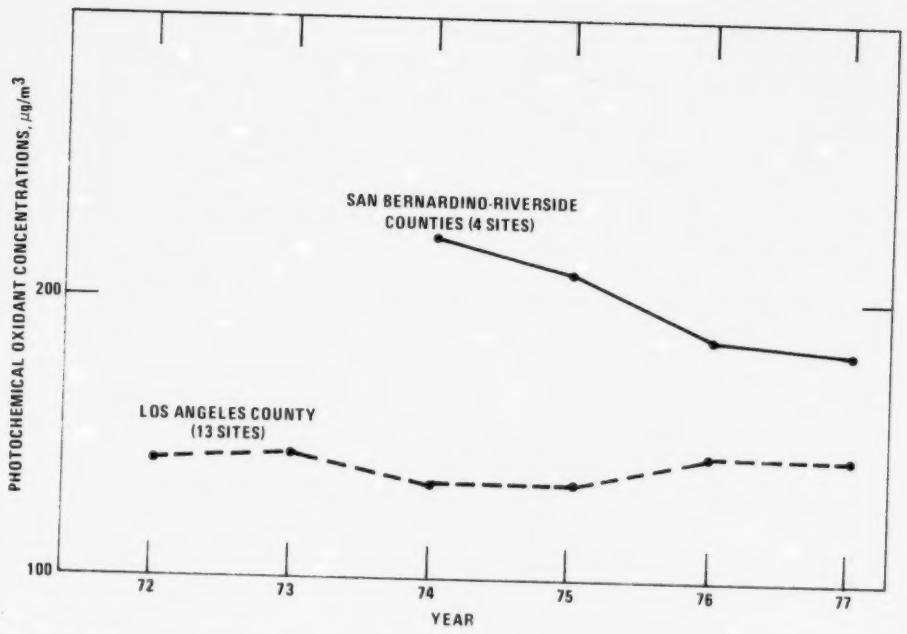


Figure 3-8. Trends in the average 90th percentile for composite ozone sites in Los Angeles and San Bernardino Riverside counties, 1972 - 1977.

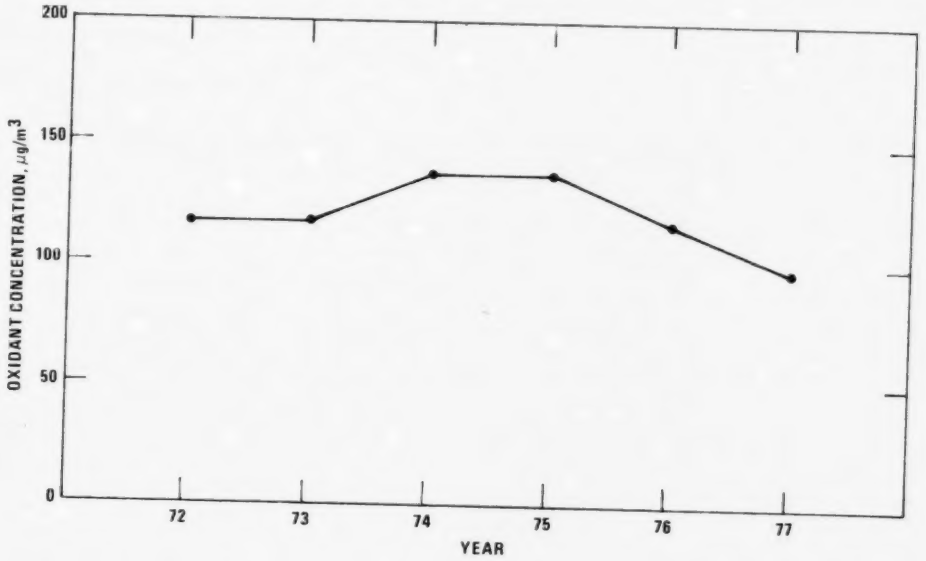


Figure 3-9. Average daily maximum-hour oxidant concentrations at 6 sites for days in April-October (1972-1977) having comparable temperatures and inversions in Bay Area Air Pollution Control District (BAAPCD).

Figure 3-8 and Figure 3-9 present trend curves for annual ozone levels for selected areas in California. The composite average of the 90th percentiles for 13 sites in Los Angeles county appears stable over the 1972-77 period (Figure 3-8). In contrast, 4 sites in Riverside and San Bernardino Counties showed decreases over this time period. Figure 3-9 shows that the composite average for the San Francisco Bay area has decreased since 1974. These data are not 90th percentile values but rather an average of the maximum hourly average O_3 concentrations of days having comparable temperature and inversion conditions conducive to elevated O_3 levels. In this manner, the effects of year-to-year variations in meteorology were isolated. The San Francisco data showed a drop in O_3 concentrations for the last 3 years to an all time low of 0.05 ppm.

3.5 TRENDS IN NITROGEN DIOXIDE: 1972-77

Trends in nitrogen dioxide (NO_2) levels were investigated for 518 sites throughout the Nation over the 1972-77 period. Of these sites, 45 were located in the State of California. The NO_2 concentration levels appear to be increasing. Most of the sites showed less than 10% increase or decrease. With most of the sites having 4 or fewer years of data, these trends can only be described as tentative. Only 28 of the 518 sites showed a statistically significant trend.

Sites were selected for this analysis if they had at least 3 years of data with at least 4000 hourly observations per year. Most of the sites satisfying this criterion (479 of 518 sites) had either 3 or 4 years of data. Much of the data was collected by the 24-hour sodium arsenite method which began to be used extensively in about 1974. Because of the incompleteness of data for the 1972 and 1973 years, the NO_2 trends presented here more closely represent the years 1974-77 rather than the entire 6-year period.

3.5.1 Regional Trends: 1972-77

Table 3-1 lists the numbers of sites by EPA Region classified according to three trend categories. The annual mean was used as the test statistic since the NO_2 data represent both hourly and 24-hour observations and since the only air quality standard for NO_2 is written in terms of an annual average. Overall, there were many more sites showing increases (312) than decreases (176). Regions 4, 5, and 6 accounted for most of the increases. The increases in Region 4 primarily reflect data from Kentucky which showed increasing NO_2 levels in 79 out of 102 sites. Increases were spread evenly within Region 5 and 7, no single State had a disproportionate share of the data. Region 2, on the other hand, has 17 of 19 sites showing downward trends; a review of the data from Region 2 revealed that most of the sites had only 3 years of data, with 1977 data usually missing.

Table 3-1. NITROGEN DIOXIDE TRENDS IN THE ANNUAL MEAN, 1972-77

Trend direction	EPA REGIONS											
	1	2	3	4	5	6	7	8	9		10	Total
									CA	Other		
Down	16	17	17	38	50	3	12	4	15	2	2	176
No change	1	0	7	5	9	1	2	0	4	0	1	30
Up	9	2	26	119	86	7	27	6	26	2	2	312
Total	26	19	50	162	145	11	41	10	45	4	5	518

Figure 3-10 shows the distribution of the yearly percent rate of change for the annual NO_2 mean concentration. The greatest percentage of sites showed upward trends. Of the 518 sites, only 28 (20 up and 8 down) showed statistically significant NO_2 trends. Of the 28, 16 are located in Kentucky. Four sites in California showed significant trends (2 positive and 2 negative).

3.5.2 California and Non-California Trends: 1972-77

As with photochemical oxidants, composite NO_2 averages were calculated for areas having extensive monitoring data. Trends in composite NO_2 averages for 1972-77 are shown in Figure 3-11 for Los Angeles County, Orange County, the Riverside-San Bernardino area, and the San Francicso Bay area. Figure 3-11 also shows NO_2 trends for 1974-77 in Atlanta, Cleveland, and Louisville. The Los Angeles County data showed a decrease from 1972 to 1974, followed by increases for 1975-77. The Riverside-San Bernardino data showed decreases to 1976, followed by an increase in 1977. The Orange County averages increased slightly over the 6-year period; however, these data represent only two sites. The San Francisco Bay area showed a stable trend from 1973-1977. Analyis of data for the three cities outside of California reveals that NO_2 trends were stable in Cleveland and Louisville since 1974 and in Atlanta since 1975.

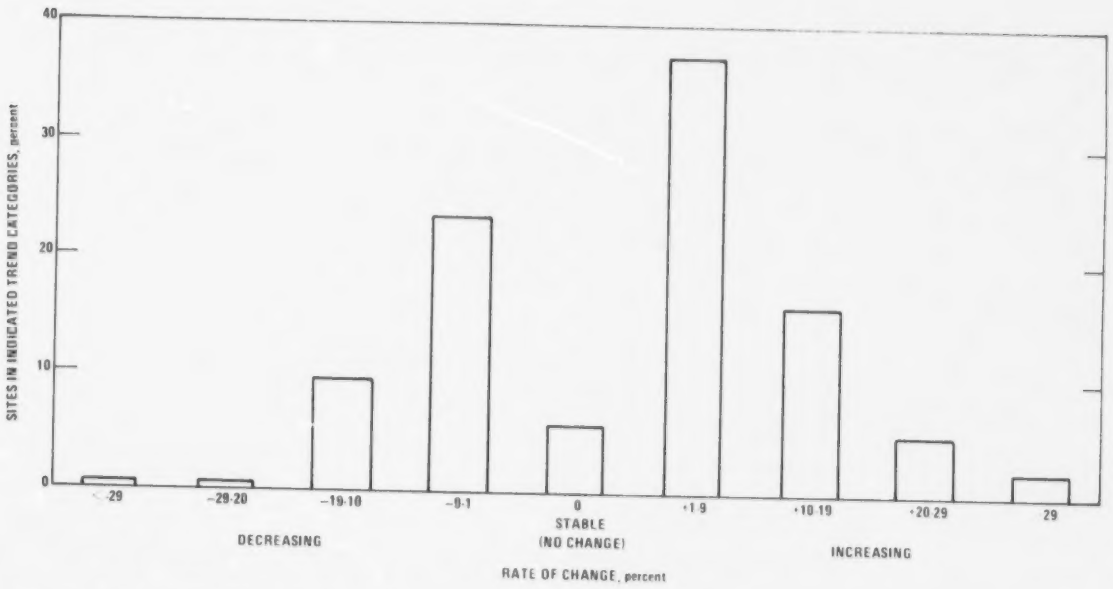


Figure 3-10. Distribution of yearly percent rate of change in annual nitrogen dioxide concentrations, 1972 - 1977.

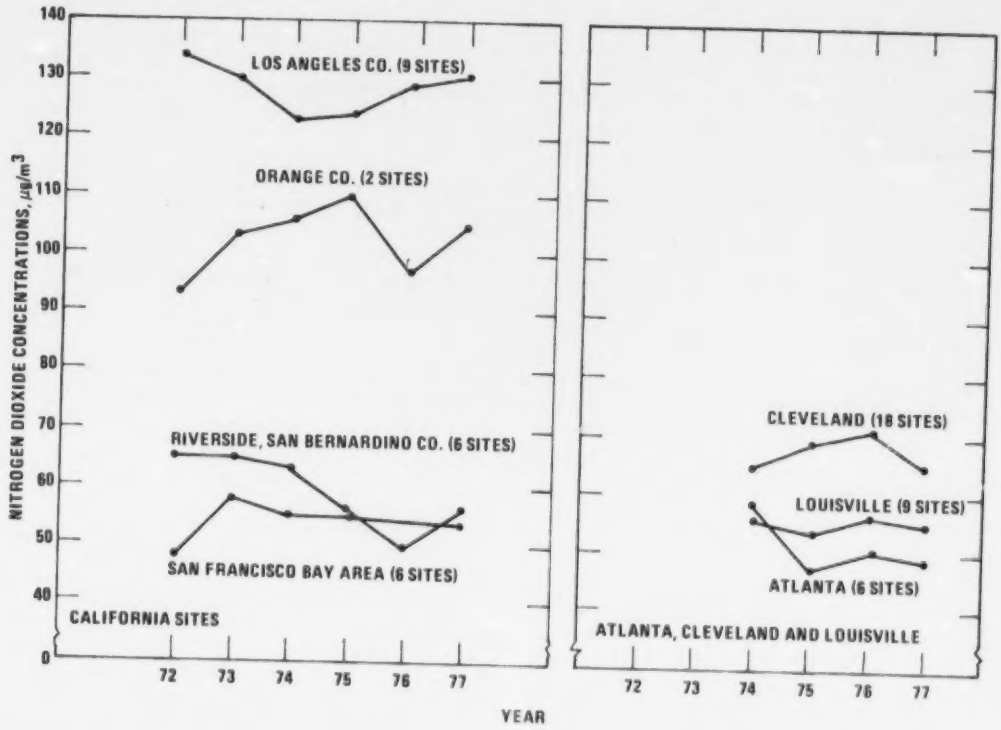


Figure 3-11. Selected trends in composite annual nitrogen dioxide averages, 1972 - 1977.

3.6 REFERENCES

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4. STATUS OF AIR QUALITY MONITORING

This section primarily documents the number of stations reporting air quality data by pollutant and measurement method for the year 1977. These data are submitted for storage to the National Aerometric Data Bank (NADB) and are used for the assessment of nationwide progress in achieving and maintaining National Ambient Air Quality Standards (NAAQS) (Table 4-1). The summaries which follow are based on air monitoring sites operated by the Federal, State, and local air pollution control agencies.

Considerable thought has been given to various ways to improve the Nation's ambient air quality monitoring programs.[1] A streamlined, high-quality, more cost-effective national air monitoring program is the goal of regulatory changes proposed by the U.S. Environmental Protection Agency.[2]

The revisions proposed after discussion and compromise with the States would:

- Set stringent requirments for a refined national monitoring network in areas with high population and pollutant concentrations to provide a sound data base for assessing national trends;
- Give the States flexibility to use resources freed from State Implementation Plan (SIP) monitoring work to meet their own needs;
- Establish uniform criteria for siting, quality assurance, equivalent analytical methodology, sampling intervals, and instrument selection to assure consistent data reporting among the States;
- Establish a standard national pollutant reporting index and require it for major metropolitan areas; and
- Provide precision and accuracy estimates with the air quality data to enable better interpretation of data quality.

The proposed revisions are designed to correct monitoring program deficiencies identified by a Federal-State-local working group established by EPA in October, 1975. In addition, the changes are intended to carry out the mandate for establishing a uniform national network required by Section 319 of the Clean Air Act Amendments of 1977.

The monitoring requirements would be directed primarily at pollutants regulated by NAAQS.

4.1 SIP Monitoring to SLAMS, NAMS and SPM

In the newly defined program, States would establish a State Implementation Plan (SIP) network of State and Local Air Monitoring Stations (SLAMS). The full network would have to be in place by January 1, 1983. States would have to evaluate the SLAMS network annually and to add, delete, or relocate monitoring stations to satisfy their own as well as EPA data needs. Overall, EPA expects that States would have fewer stations in the SLAMS network than under the current implementation plan monitoring porgram.

Data from the SLAMS network would be sent to EPA's National Aerometric Data-Bank in an annual summary report, eliminating currently required quarterly reporting of individual values. Reporting of individual values to EPA regions would depend on agreements reached between the States and regional offices.

States may have additional monitoring stations that are not part of the SLAMS network. These would be called special purpose monitoring (SPM) stations. They would not be subject to EPA requirements unless the information is used for implementation plan purposes.

In addition, States would operate selected stations from the SLAMS network to provide EPA with data for making nationwide assessments and establishing National trends. The stations would continue as part of the SLAMS network but would be called National Air Monitoring Stations (NAMS). The NAMS would be located in areas of highest pollutant concentration and high population density. These individual data values will be submitted to EPA's National Aerometric Data Bank on a scheduled basis.

Table 4-1. NATIONAL AMBIENT AIR QUALITY STANDARDS

Pollutant	Time period/standard	Maximum permissible concentration[c]	
Suspended particulate matter (Total suspended particulates) (TSP)	Annual, Secondary[a]	60 $\mu g/m^3$	-
	Annual, primary[b]	75 $\mu g/m^3$	-
	24-hr, secondary	150 $\mu g/m^{3d}$	-
	24-hr, primary	260 $\mu g/m^{3d}$	-
Sulfur dioxide (SO_2)	Annual, primary	80 $\mu g/m^3$	.03 ppm
	24-hr, primary	365 $\mu g/m^{3d}$	.14 ppm
	3-hr, secondary	1300 $\mu g/m^{3d}$	.50 ppm
Carbon monoxide (CO)	1-hr, primary	40 mg/m^3	35.00 ppm
	8-hr, primary	10 mg/m^3	9.00 ppm
Oxidants/ozone (O_3)	1-hr, primary	160 $\mu g/m^{3d}$	.08 ppm
Nitrogen dioxide (NO_2)	Annual, primary	100 $\mu g/m^{3d}$	.05 ppm

[a]Secondary: to protect public welfare.
[b]Primary: to protect public health.
[c]The maximum permissible concentration is given in micrograms per cubic meter ($\mu g/m^3$), milligrams per cubic meter (mg/m^3), and/or parts per million (ppm).
[d]These values are not to be exceeded more than once per year.

The number of stations in the State's NAMS network would be far less than are currently in the State's SIP network. The deadline for completing the NAMS network would be January 1, 1981, two years before completion of the SLAMS network.

Future trends reports will focus on summaries of air monitoring sites based on the NAMS and SLAMS designations. The intention of this section is to document the extent of monitoring in 1977 during the time of transition to the new national monitoring program.

4.2 NATIONAL MONITORING SUMMARY, 1976-77

Between 1976 and 1977 there has been an increase in the number of monitors reporting carbon monoxide (CO) and ozone (O_3) (Table 4-2). The other pollutants - total suspended particulate (TSP), sulfur dioxide (SO_2), oxidant, and nitrogen dioxide (NO_2) - show a decrease (Table 4-2). The total number of monitoring sites for all pollutants decreased from 9278 in 1976 to 8880 in 1977 for a net decrease of 4.3%.

The State agencies operate the majority of monitoring sites (60.4%), followed by the local agencies (36.7%) with the Federal government a distant third (2.9%) (Table 4-3). As documented in past trends reports,[3-6] TSP continues to predominate with 4008 of a total of 8880 monitors (45.1%). TSP is followed by SO_2, NO_2, O_3, CO, and oxidants in that order.

4.3 SUMMARY OF STATIONS VIOLATING STANDARDS, 1977

The pollutants oxidant/ozone have the highest percentage of sites exceeding standards (86%) (Table 4-4). This is followed by carbon monoxide with 46% of the CO sites violating the 8-hour primary

Table 4-2 TOTAL MONITORS REPORTING (U.S.) BY POLLUTANT AND METHOD, 1976 and 1977 (INCLUDES FEDERAL, STATE AND LOCAL)

Pollutant	No. of Monitors Reporting 1976	1977
Total Suspended Particulate (TSP)		
Hi-volume sampler	**4095**	**4008**
Sulfur Dioxide (SO_2)		
Continuous		
West-Gaeke - Colorimetric-hourly	82	95
Conductometric	20	25
Coulometric	339	365
Flame photometric	121	105
Hydrogen peroxide NAOH titratton	11	76
Catalyst - flame photometric	1	1
Pulsed flourescent	17	--
Sec. deriv. spectroscopy	2	--
Sequential - conductimetric	10	9
Total Continuous SO_2	603	676
24-hour bubbler		
Pararosaniline - sulfamic acid	1879	1689
Total SO_2	**2482**	**2365**
Carbon monoxide (CO)		
Continuous		
Nondispersive infrared (NDIR)	384	401
Flame ionization	64	55
Total CO	**448**	**456**
Ozone (O_3)		
Continuous		
Chemiluminescence	352	348
Ultraviolet dasibi	118	134
Total O_3	**470**	**482**
Oxidant (O_x)		
Continuous		
Colorimetric	51	40
Coulometric - neutral KI	24	2
Total O_x	**75**	**42**
Nitrogen dioxide (NO_2)		
Continous		
Colorimetric - Lyshkow - mod.	109	708
Saltzman - colorimetric	5	21
Coulometric	4	4
Chemiluminescence	139	170
	257	273
24-hour bubbler		
NASN sodium arsenite - orifice	1186	1029
NASN sodium arsenite - frit	260	220
TGS method - frit	5	5
	1451	1254
Total NO_2	**1708**	**1527**

Table 4-3 TOTAL MONITORS IN U.S. OPERATED BY FEDERAL, STATE, AND LOCAL AGENCIES

Pollutants	Monitors, by agency			Total Monitors
	Federal	State	Local	
Total suspended particulates	90	2588	1330	4008
Sulfur dioxide	69	1470	826	2365
Continuous methods	(8)[a]	(416)	(252)	(676)
Bubbler methods	(61)	(1054)	(574)	(1689)
Carbon monoxide	4	233	219	456
Nitrogen dioxide	81	815	631	1527
Continous methods	(24)	(121)	(148)	(293)
Bubbler methods	(57)	(694)	(483)	(1234)
Ozone	10	256	216	482
Oxidants	0	5	37	42
Total	254	5367	3259	8880

[a]Subtotals are in parenthesis.

Table 4-4 NATIONAL SUMMARY OF TOTAL STATIONS REPORTING DATA AND NUMBER REPORTING VIOLATIONS OF AIR QUALITY STANDARDS, 1977

Pollutants	Data Record and standard exceeded	Number of stations	Percent of sites exceeding NAAQS
TSP	Valid annual data[a]	2699	
	Annual sec. (guide only)	1070	40
	Annual primary	465	17
	At least minimal data[b]	4008	
	24-Hour secondary	1424	36
	24-Hour primary	314	8
SO_2	Valid annual data[a]	1355	
	Annual primary	19	1
	At least minimal data[b]	2365	
	24-Hour primary	58	2
	3-Hour secondary	30	1
CO	At least minimal data[b]	456	
	1-Hour primry	11	2
	8-Hour primary	211	46
OX/O_3	At least minimal data[b]	524	
	1-Hour primary	452	86
NO_2	At least minimal data[b]	1527	
	Valid annual data[a]	933	
	Annual primary	18	2

[a]Valid annual data record must contain at least five of the scheduled 24-hour samples per quarter for EPA recommended intermittant sampling (once every 6 days) or 75% of all possible values in a year for continuous instruments.

[b]Minimal data consist of at least three 24-hour samples for intermittant sampling monitors or 400 hourly values for continuous instruments.

standard. TSP has 17% of its sites violating the annual primary standard and 8% violating the 24-hour primary standard. Sites monitoring SO_2 and NO_2 have negligible violations-only 2% violate the primary 24-hour SO_2 standard and 2% violate the annual primary NO_2 standard.

A detailed summary of stations reporting and violating NAAQS by State is presented in Table 4-5. This table lists the number of continuous monitoring sites reporting at least 400 hourly values and the number of 24-hour bubbler sites reporting at least three values. It also lists the number of sites exceeding the primary and secondary standards. A full year's data record must contain at least five of the scheduled 24-hour samples per quarter for intermittent (once every six days) sampling for TSP, SO_2, and NO_2. For continuous samplers 75 percent of all possible values in the year are required.

Table 4-5. NUMBER OF STATIONS REPORTING AND NUMBER OF STATIONS AT WHICH STANDARDS WERE EXCEEDED, BY STATE, 1977

STATE	YR UG/CU.M. P.P.M.	SUSPENDED PARTICULATES ANNUAL # STA (1)	SUSPENDED PARTICULATES ANNUAL #> SEC 60	SUSPENDED PARTICULATES ANNUAL #> PRI 75	SUSPENDED PARTICULATES 24-HOUR # STA (2)	SUSPENDED PARTICULATES 24-HOUR #> SEC 150	SUSPENDED PARTICULATES 24-HOUR #> PRI 260	SULFUR DIOXIDE ANNUAL # STA (1)	SULFUR DIOXIDE ANNUAL #> STD 80 .03	SULFUR DIOXIDE 24-HR # STA (2)	SULFUR DIOXIDE 24-HR #> STD 365 .14	SULFUR DIOXIDE 3-HR #> STD 1300 .50	CARBON MONOXIDE 1-HR # STA (2)	CARBON MONOXIDE 1-HR #> STD 40. 35	CARBON MONOXIDE 8-HR #> STD 10. 9	OXIDANTS 1-HR # STA (2)	OXIDANTS 1-HR #> STD 160 .08	NITROGEN DIOXIDE # STA (2)	NITROGEN DIOXIDE # STA (1)	NITROGEN DIOXIDE #>AN STD 100

Number of NO_2 stations at which annual standard was exceeded.
Number of NO_2 stations reporting a valid year's data.
Number of NO_2 stations reporting at least minimal data.
Number of oxidant stations at which 1-hr standard was exceeded.
Number of oxidant stations reporting at least minimal data.
Number of CO stations at which 8-hr standard was exceeded.
Number of CO stations at which 1-hr standard was exceeded.
Number of CO stations reporting at least minimal data.
Number of SO_2 stations at which 3-hr standard was exceeded.
Number of SO_2 stations at which 24-hr standard was exceeded.
Number of SO_2 stations reporting at least minimal data.
Number of SO_2 stations at which annual standard was exceeded.
Number of SO_2 stations reporting a valid year's data.
Number of particulate stations at which primary 24-hr standard was exceeded.
Number of particulate stations at which secondary 24-hr standard was exceeded.
Number of particulate stations reporting at least minimal data.
Number of particulate stations at which primary annual standard was exceeded.
Number of particulate stations at which secondary annual standard was exceeded.
Number of particulate stations reporting a valid year's data.
Year

Table 4-5 Number of Stations Reporting and Number of Stations at which Standards Were Exceeded by State, 1977

STATE	YR	SUSPENDED PARTICULATES ANNUAL # STA (1)	ANNUAL #> SEC 60	ANNUAL #> PRI 75	24-HOUR # STA (2)	24-HOUR #> SEC 150	24-HOUR #> PRI 260	SULFUR DIOXIDE ANNUAL # STA (1)	ANNUAL #> STD 80 .03	24-HR # STA (2)	24-HR #> STD 365 .14	3-HR #> STD 1300 .50	CARBON MONOXIDE 1-HR # STA (2)	1-HR #> STD 40* 35	8-HR #> STD 10* 9	OXIDANTS 1-HR # STA (2)	1-HR #> STD 160 .08	NITROGEN DIOXIDE # STA (2)	# STA (1)	#>ANN STD 100
01 ALABAMA	77	50	12	6	95	25	8	3	0	34	1	1	4	0	0	8	8	15	5	0
02 ALASKA	77	12	3	1	27	12	5	1	0	7	0	0	6	2	6	0	0	2	1	? 0
03 ARIZONA	77	13	10	5	52	34	9	4	?	28	5	7	16	0?	7	11	9	15	3	0
04 ARKANSAS	77	39	24	7	46	42	7	15	0	15	0	0	0	0	0	3	3	16	11	0
05 CALIFORNIA	77	0	?	?	106	39	5	35	?	70	0	0	84	0	30	114	98	89	53	15
06 COLORADO	77	60	51	26	77	55	18	6	0	8	0	0	10	1	7	8	6	7	2	1
07 CONNECTICUT	77	39	9	1	43	8	0	2	?	42	0	0	9	1	8	12	12	24	21	0
08 DELAWARE	77	10	3	1	15	1	0	9	0	15	1	0	3	0	0	0	0	0	0	0
09 DIST. COLUMBIA	77	0	?	?	10	10	2	0	0	8	0	0	9	1	5	7	5	8	2	0
10 FLORIDA	77	110	12	1	158	6	0	85	0	130	1	1	12	0	1	16	15	69	42	0
11 GEORGIA	77	43	11	4	53	8	0	28	0	38	0	0	4	0	3	1	1	29	24	0
12 HAWAII	77	9	1	1	11	0	0	8	0	10	0	0	1	0	0	1	0	2	0	0
13 IDAHO	77	30	23	17	37	33	17	10	2	13	3	2	1	1	1	0	0	1	0	0
14 ILLINOIS	77	120	77	42	162	93	18	74	?	123	2	0	20	0	4	29	26	83	59	? 0
15 INDIANA	77	43	23	6	94	30	2	37	?	89	2	0	7	1	3	14	9	64	25	0

(1) NUMBER OF STATIONS REPORTING A FULL YEAR'S VALID DATA
(2) NUMBER OF STATIONS REPORTING AT LEAST 3 24-HR VALUES OR 400 HOURLY VALUES
? STATIONS WITH INCOMPLETE DATA MAY BE EXCEEDING THE ANNUAL STANDARD;
* CO STANDARDS ARE IN MILLIGRAMS PER CUBIC METER

Table 4-5 (Continued)

STATE	YR	SUSPENDED PARTICULATES ANNUAL #	#> SEC 60	#> PRI 75	24-HOUR #	#> SEC 150	#> PRI 260	SULFUR DIOXIDE ANNUAL #	#> STD 80 .03	24-HR #	#> STD 365 .14	3-HR #> STD 1300 .50	CARBON MONOXIDE 1-HR #	1-HR #> STD 40* 35	8-HR #> STD 10* 9	OXIDANTS 1-HR #	1-HR #> STD 160 .08	NITROGEN DIOXIDE #	#	#>ANN STD 100
	UG/CU.M: P.P.M:	STA (1)			STA (2)			STA (1)		STA (2)			STA (2)			STA (2)		STA (2)	STA (1)	
16 IOWA	77	56	37	17	71	42	12	30	0	34	2	1	5	0	3	6	6	12	7	0
17 KANSAS	77	52	24	10	65	25	4	38	0	48	1	0	7	0	6	7	5	43	37	0
18 KENTUCKY	77	106	52	24	130	50	4	95	?	130	0	0	15	0	3	14	12	124	94	0
19 LOUISIANA	77	24	3	0	30	2	1	14	0	18	0	0	0	0	0	6	6	16	14	0
20 MAINE	77	24	1	?	42	14	1	21	?	34	1	0	4	0	4	1	1	6	3	0
21 MARYLAND	77	53	16	8	88	19	3	40	?	93	0	0	15	0	6	16	15	85	43	0
22 MASSACHUSETTS	77	37	6	2	56	6	3	14	0	76	0	0	9	0	9	11	11	23	8	0
23 MICHIGAN	77	110	32	12	141	49	3	32	0	46	0	0	11	0?	5	14	10	23	14	1
24 MINNESOTA	77	57	14	4	73	20	2	31	2	52	2	1	8	0	7	4	4	34	19	0
25 MISSISSIPPI	77	16	6	?	34	2	0	2	0	24	0	0	0	0	0	3	3	4	1	0
26 MISSOURI	77	50	34	13	78	36	6	14	?	37	2	2	14	0	7	14	10	20	6	0
27 MONTANA	77	18	3	1	53	17	5	6	1	21	8	6	4	0	3	4	2	9	0	0
28 NEBRASKA	77	42	26	16	52	15	3	12	0	16	0	0	3	0	3	1	1	11	7	0
29 NEVADA	77	0	?	?	46	18	2	0	0	4	1	1	3	0?	3	5	3	3	1	0
30 NEW HAMPSHIRE	77	23	C	0	29	1	0	15	?	29	1	0	3	0	0	5	4	16	12	0

(1) NUMBER OF STATIONS REPORTING A FULL YEAR'S VALID DATA
(2) NUMBER OF STATIONS REPORTING AT LEAST 3 24-HR VALUES OR 400 HOURLY VALUES
? STATIONS WITH INCOMPLETE DATA MAY BE EXCEEDING THE ANNUAL STANDARD;
* CO STANDARDS ARE IN MILLIGRAMS PER CUBIC METER

Table 4-5 (Continued)

STATE	YR	SUSPENDED PARTICULATES ANNUAL # STA (1)	#> SEC 60 -	#> PRI 75 -	24-HOUR # STA (2)	#> SEC 150 -	#> PRI 260 -	SULFUR DIOXIDE ANNUAL # STA (1)	#> STD 80 .03	24-HR # STA (2)	#> STD 365 .14	3-HR #> STD 1300 .50	CARBON MONOXIDE 1-HR # STA (2)	#> STD 40* 35	8-HR #> STD 10* 9	OXIDANTS 1-HR # STA (2)	#> STD 160 .08	NITROGEN DIOXIDE # STA (2)	# STA (1)	#>ANN STD 100
31 NEW JERSEY	77	60	5	2	66	2	0	29	0	30	0	0	22	2	15	6	6	14	13	0
32 NEW MEXICO	77	54	33	22	66	51	21	26	0	31	0	0	10	0	6	2	0	21	19	0
33 NEW YORK	77	225	20	8	314	29	5	94	3	141	3	0	29	0	9	31	28	20	2	? 0
34 NORTH CAROLINA	77	81	21	2	111	3	1	36	0	66	0	0	1	0	1	4	4	65	34	0
35 NORTH DAKOTA	77	32	3	1	37	9	4	14	0	17	0	0	0	0	0	2	1	17	15	0
36 OHIO	77	277	189	74	336	166	32	140	7	212	8	2	16	1	6	32	29	178	120	? 0
37 OKLAHOMA	77	44	21	8	61	38	6	19	0	27	0	0	4	1	3	5	5	20	15	1
38 OREGON	77	39	10	6	42	15	2	7	0	13	0	0	5	0	5	5	5	3	1	0
39 PENNSYLVANIA	77	0	?	?	132	71	29	6	3	21	4	0	13	0	6	10	10	8	1	0
40 PUERTO RICO	77	0	?	?	11	3	0	0	0	9	0	0	0	0	0	0	0	9	0	0
41 RHODE ISLAND	77	11	2	2	15	3	0	1	0	13	0	0	1	0	1	2	2	4	2	0
42 SOUTH CAROLINA	77	42	11	1	69	7	0	32	0	59	0	0	3	0	2	2	2	48	32	0
43 SOUTH DAKOTA	77	13	3	0	23	4	0	0	0	6	0	0	0	0	0	0	0	5	0	0
44 TENNESSEE	77	67	38	15	98	30	2	17	0	58	0	0	5	0	4	10	10	56	24	0
45 TEXAS	77	163	108	52	193	142	43	117	0	144	0	0	19	0	1	25	22	142	114	0

(1) NUMBER OF STATIONS REPORTING A FULL YEAR'S VALID DATA
(2) NUMBER OF STATIONS REPORTING AT LEAST 3 24-HR VALUES OR 400 HOURLY VALUES
? STATIONS WITH INCOMPLETE DATA MAY BE EXCEEDING THE ANNUAL STANDARD;
* CO STANDARDS ARE IN MILLIGRAMS PER CUBIC METER

Table 4-5 (Continued)

STATE	YR	SUSPENDED PARTICULATES ANNUAL #	ANNUAL #> SEC 60	ANNUAL #> PRI 75	24-HOUR #	24-HOUR #> SEC 150	24-HOUR #> PRI 260	SULFUR DIOXIDE ANNUAL #	ANNUAL #> STD 80 .03	24-HR #	24-HR #> STD 365 .14	3-HR #> STD 1300 .50	CARBON MONOXIDE 1-HR #	1-HR #> STD 40* 35	8-HR #> STD 10* 9	OXIDANTS 1-HR #	1-HR #> STD 160 .08	NITROGEN DIOXIDE #	#	#>ANN STD 100
	UG/CU.M:	STA (1)	-	-	STA (2)	-	-	STA (1)	-	STA (2)	-	-	STA (2)	-	-	STA (2)	-	STA (2)	STA (1)	-
	P.P.M:																			
46 UTAH	77	16	10	7	27	23	14	4	?	23	7	5	6	0	4	6	4	13	6	0
47 VERMONT	77	8	1	1	11	2	0	1	0	6	0	0	2	0	0	3	3	0	0	0
48 VIRGINIA	77	142	32	7	157	16	1	73	0	81	1	0	15	0	4	19	18	13	13	0
49 WASHINGTON	77	52	21	10	63	32	9	11	0	22	0	0	7	0	6	7	5	3	3	0
50 WEST VIRGINIA	77	30	8	4	40	23	1	19	?	29	0	0	2	0	0	2	1	1	0	0
51 WISCONSIN	77	63	20	8	105	36	3	19	1	45	4	1	9	0	4	14	13	17	0	0
52 WYOMING	77	30	1	1	44	3	0	6	0	13	0	0	0	0	0	2	0	13	5	0
54 GUAM	77	0	?	?	3	2	1	0	0	4	0	0	0	0	0	0	0	4	0	0
55 VIRGIN ISLANDS	77	4	0	0	4	2	0	3	0	3	0	0	0	0	0	0	0	0	0	0
TOTAL	77	2699	1070	456	4008	1424	314	1355	19	2365	58	30	456	11	211	524	452	1527	933	18

(1) NUMBER OF STATIONS REPORTING A FULL YEAR'S VALID DATA
(2) NUMBER OF STATIONS REPORTING AT LEAST 3 24-HR VALUES OR 400 HOURLY VALUES
? STATIONS WITH INCOMPLETE DATA MAY BE EXCEEDING THE ANNUAL STANDARD;
* CO STANDARDS ARE IN MILLIGRAMS PER CUBIC METER

4.4 REFERENCES

1. **Air Monitoring Strategies for State Implementation Plans,** Standard Air Monitoring Work Group, U.S. Environmental Protection Agency, Research Triangle Park, N.C. Publication No. EPA-45p/2-77-010.

2. **Federal Register,** Vol. 43, August 7, 1978, p. 34930.

3. **The National Air Monitoring Program: Air Quality and Emission Trends - Annual Report,** Volumes 1 and 2. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, N.C. Publication No. EPA-450/1-73-001 a and b. July 1973.

4. **Monitoring and Air Quality Trends Reports, 1972.** U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, N.C. Publication No. EPA-450/1-73-004. December 1973.

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6. **Monitoring and Air Quality Trends Report, 1974.** U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, N.C. Publication No. EPA-450/1-76-001. February 1976.

5. NATIONWIDE EMISSION ESTIMATES, 1970-77

Table 5-1 summarizes the annual estimated nationwide emissions of total suspended particulates (TSP), sulfur oxides (SO_x), nitrogen oxides (NO_x), volatile organic compounds (VOC), and carbon monoxide (CO) for 1970-77. Because of modifications in methodology and use of more refined emission factors, estimates in this table and in the other tables in this section should not be compared with estimates in previous trend reports.[1]

Table 5-1 SUMMARY OF NATIONAL EMISSION ESTIMATES, 1970-77
(10^6 metric tons/year)

Year	TSP	SO_x	NO_x	VOC	CO
1970	22.2	29.8	19.6	29.5	102.2
1971	20.9	28.3	20.2	29.1	102.5
1972	19.6	29.6	21.6	29.6	103.8
1973	19.2	30.2	22.3	29.7	103.5
1974	17.0	28.4	21.7	28.6	99.7
1975	13.7	26.1	21.0	26.9	96.9
1976	13.2	27.2	22.8	28.7	102.9
1977	12.4	27.4	23.1	28.3	102.7

Two distinctions between emission estimates and ambient pollutant measurements should be noted when interpreting the data in Table 5-1. First, the estimates for TSP, SO_x, and NO_x emissions include more substances than are routinely measured by ambient air monitoring equipment. For example, high-volume air samplers collect only suspended particulates approximately 0.3 to 100 microns (10^{-6} meters) in diameter, but TSP emission inventories include most suspended and settled particulates generated by man's activities. Likewise sulfur dioxide (SO_2) and nitrogen dioxide (NO_2) ambient air monitors measure only these two compounds while oxides of sulfur (SO_x) and nitrogen (NO_x) are included in the emission estimates. In each case, the substance measured by the ambient air monitor is the most prevalent constitutent of its pollutant class or is acknowledged to be its most representative indicator.

Second, estimates of oxidant emissions are not provided because most oxidant species are secondary pollutants generated by photochemical reactions in the atmosphere. Emission estimates of VOC, a major ingredient in oxidant-producing reactions, were developed from current emission factors.[2,3] Generally excluded from VOC estimates were emission of methane, ethane, methyl chloroform, and Freon 112, which are considered to be of negligible photochemical reactivity. However, these compounds were included in estimates for many stationary fuel combustion sources because sufficient information was not available to justify exclusion. Highway vehicle emissions were estimated as nonmethane VOC's.[3]

5.1 DETAILED ANNUAL EMISSION ESTIMATES

Tables 5-2 through 5-9 present annual estimates of TSP, SO_x, NO_x, VOC, and CO emissions by major source categories for the 1970-77 period. These estimates were based on published data describing fuel use and industrial production and on other EPA data describing emission factors and the extent of air pollution controls empoyed.[4-7] In each table, there are five categories: transportation, stationary fuel combustion, industrial processes, solid waste, and miscellaneous sources.

The "transportation" category includes emissions from all mobile sources. Highway vehicles include passenger cars, trucks, and buses. Nonhighway vehicles include aircraft, trains, shipping, and miscellaneous mobile sources such as farm equipment, industrial and construction machinery, lawnmowers, and snowmobiles.

Stationary fuel combustion is defined as fuel use in nonmobile combustion equipment such as boilers and stationary internal combustion engines. Emissions are shown for electric utility power plants, industrial establishments, and other fuel consumers (residential, commercial, governmental and educational).

Industrial processes include emissions from the operation of process equipment by manufacturing industries. In addition, the related subcategories oil and gas production and marketing (crude oil and natural gas production, petroleum storage tanks and transfer facilities, and gasoline service stations) and industrial organic solvent use (surface coating and degreasing of manufactured products, printing, and publishing) are included under industrial processes. Other processes represent emissions from the pulp and paper, wood products, agricultrual, rubber and plastics, and textile industries.

Solid waste includes emissions from the combustion of waste in municipal and other incinerators and from the open burning of domestic and municipal refuse. Miscellaneous sources include emissions from the combustion of forest, agricultural, and coal refuse; from structural fires; and from the consumption of organic solvents not accounted for in industrial processing operation. Non-industrial solvent use includes surface coatings, dry cleaning, and cutback asphalt paving.

5.2 ANALYSIS OF THE DATA IN EMISSION TRENDS

Table 5-1 indicates that from 1970 to 1977, TSP emissions decreased by 44%, SO_x emissions decreased by 8%, NO_x emissions increased by 18%, VOC emissions decreased by 4%, and CO emissions showed no significant change. These data represent calculated estimates for the nation as a whole; they are indicative of general overall trends, rather than local trends, in the quantities of pollutants released to the atmosphere.

The substantial decrease in TSP emissions from 1970 to 1977 was primarily due to installation of control equipment on industrial process and coal-fired stationary fuel combustion sources. In addition, TSP emissions have decreased because of less burning of solid waste.

A slight decrease in SO_x emissions was observed from 1970 to 1977. Most SO_x emissions result from the combustion of coal and residual fuel oil by electric utilities. Although utility coal use increased by about 50% and residual oil use by about 70% from 1970 to 1977, emissions from electric utilities increased by only 10% during this period due to the use of fuels with lower sulfur content. Emissions of SO_x from industrial processes were significantly lower in 1977 than in 1970, due mainly to controls used by primary nonferrous smelters and EPA regulations prescribing lower emissions from sulfuric acid manufacturing plants.

The increase in NO_x emissions resulted primarily from increased fuel use by electric utilities and increased highway motor vehicle travel. Industrial process emissions remained about the same. Solid waste emissions decreased.

A slight decrease in VOC emissions was observed from 1970-1977. The 17% increase in industrial process emissions due to industrial growth during this period was offset by decreases in emissions from other categories. Emissions from highway vehicles decreased by 7% as a result of Federally mandated motor vehicle emission controls, despite an estimated 30% increase in motor vehicle travel from 1970 to 1977. Solid waste emissions decreased because less solid waste was burned. Miscellaneous organic solvent emissions decreased due to the substitution of water-based emulsified asphalts for those liquefied with petroleum distillates.

Overall, CO emissions did not change substantially from 1970-1977. An emission reduction resulting from less burning of solid wastes and agricultural materials was offset by a 9% increase in emissions from highway motor vehicles. As stated in Section 3.3, the emissions per vehicle mile traveled (VMT) actually decreased due to emission controls, but, were more than offset by an even greater increase in VMT. Therefore, the net effect was an overall increase in total CO emissions.

These CO emission trends differ from last year's report,[1] because of a change in the calculation of emission factors. The data in last year's report were based on vehicle emission factors given in reference 2. The emission estimates for 1970-77 in this report have been revised upward according to new data and a new calculation methodology.[3] These estimates incorporate new emission factors[3]

based on the measured emissions of in-use vehicles through model-year 1975 and on analytical estimates of emissions for the 1976 and 1977 model-year vehicles. Previous emission factors[2] were based on measured vehicular emissions through calendar year 1972 and projected emissions factors for subsequent years.

5.3 REFERENCES

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3. **Mobile Source Emission Factors.** U.S. Environmental Protection Agency, Office of Transportation and Land Use Policy, Washington, D.C. Publication NO. EPA-400/9-78-005. March 1978.

4. Mann, C.O. OAQPS Data Files of Nationwide Emissions, 1970-1976. Unpublished documents, National Air Data Branch, Monitoring and Data Analysis Division, U.S. Environmental Protection Agency, Research Triangle Park, N.C., November 1977.

5. Data from Compliance Data System, Division of Stationary Source Enforcement, U.S. Environmental Protection Agency, Washington, D.C., June 1977.

6. Data from Energy Data System, Energy Strategies Branch, Strategies and Air Standards Division, U.S. Environmental Protection Agency, Research Triangle Park, N.C. April 1977.

7. Data from National Emissions Data System, National Air Data Branch, Monitoring and Data Analysis Division, U.S. Environmental Protection Agency, Research Triangle Park, N.C. November 1977.

Table 5-2 NATIONWIDE EMISSION ESTIMATES, 1970
(10^6 metric tons/year)

Source category	TSP	SO_x	NO_x	VOC	CO
Transportation	1.2	0.7	7.4	12.2	80.5
Highway vehicles	0.7	0.3	5.3	10.6	70.9
Non-highway vehicles	0.5	0.4	2.1	1.6	9.6
Stationary fuel combustion	7.1	22.6	11.1	1.5	1.3
Electric utilities	4.1	15.9	5.2	0.1	0.2
Industrial	2.6	4.6	5.1	1.3	0.6
Residential, commercial, and institutional	0.4	2.1	0.8	0.1	0.5
Industrial processes	11.9	6.3	0.6	8.6	8.0
Chemicals	0.3	0.5	0.2	2.0	2.9
Petroleum refining	0.1	0.7	0.3	0.9	2.1
Metals	2.1	4.3	0	0.2	2.1
Mineral products	7.8	0.6	0.1	0	0
Oil and gas production and marketing	0	0.1	0	2.7	0
Industrial organic solvent use	0	0	0	2.6	0
Other processes	1.6	0.1	0	0.2	0.9
Solid waste	1.1	0.1	0.3	1.7	6.2
Miscellaneous	0.9	0.1	0.2	5.5	6.2
Forest wildfires and managed burning	0.5	0	0.1	0.7	4.3
Agricultural burning	0.3	0	0	0.3	1.5
Coal refuse burning	0.1	0.1	0.1	0.1	0.3
Structural fires	0	0	0	0	0.1
Miscellaneous organic solvent use	0	0	0	4.4	0
Total	22.2	29.8	19.6	29.5	102.2

Note: A zero indicates emissions of less than 50,000 metric tons per year.

Table 5-3 NATIONWIDE EMISSION ESTIMATES, 1971
(10^6 metric tons/year)

Source category	TSP	SO_x	NO_x	VOC	CO
Transportation	1.1	0.7	7.9	12.2	81.1
Highway vehicles	0.7	0.3	5.8	10.6	71.7
Non-highway vehicles	0.4	0.4	2.1	1.6	9.4
Stationary fuel combustion	6.6	21.6	11.3	1.5	1.4
Electric utilities	4.0	15.7	5.4	0.1	0.2
Industrial	2.2	4.0	5.1	1.3	0.6
Residential, commercial, and institutional	0.4	1.9	0.8	0.1	0.6
Industrial processes	11.3	5.8	0.6	8.8	7.9
Chemicals	0.2	0.5	0.2	2.0	2.7
Petroleum refining	0.1	0.7	0.3	0.9	2.1
Metals	1.9	3.8	0	0.2	2.2
Mineral products	7.4	0.6	0.1	0	0
Oil and gas production and marketing	0	0.1	0	2.8	0
Industrial organic solvent use	0	0	0	2.7	0
Other processes	1.7	0.1	0	0.2	0.9
Solid waste	0.8	0.1	0.2	1.3	4.7
Miscellaneous	1.1	0.1	0.2	5.3	7.4
Forest wildfires and managed burning	0.7	0	0.2	1.0	5.9
Agricultural burning	0.2	0	0	0.2	1.2
Coal refuse burning	0.1	0.1	0	0	0.2
Structural fires	0.1	0	0	0	0.1
Miscellaneous organic solvent use	0	0	0	4.1	0
Total	20.9	28.3	20.2	29.1	102.5

Note: A zero indicates emissions of less than 50,000 metric tons per year.

Table 5-4 NATIONWIDE EMISSION ESTIMATES, 1972
(10^6 metric tons/year)

Source category	TSP	SO_x	NO_x	VOC	CO
Transportation	1.2	0.7	8.7	12.5	85.4
Highway vehicles	0.8	0.3	6.4	10.9	76.1
Non-highway vehicles	0.4	0.4	2.3	1.6	9.3
Stationary fuel combustion	6.4	22.0	11.9	1.5	1.3
Electric utilities	4.1	16.2	5.9	0.1	0.2
Industrial	2.0	4.0	5.1	1.3	0.6
Residential, commercial, and institutional	0.3	1.8	0.9	0.1	0.5
Industrial processes	10.6	6.7	0.7	9.3	7.9
Chemicals	0.2	0.6	0.3	2.2	2.5
Petroleum refining	0.1	0.7	0.3	0.9	2.2
Metals	1.9	4.5	0	0.2	2.3
Mineral products	6.9	0.7	0.1	0	0
Oil and gas production and marketing	0	0.1	0	2.9	0
Industrial organic solvent use	0	0	0	2.9	0
Other processes	1.5	0.1	0	0.2	1.0
Solid waste	0.7	0.1	0.2	1.1	4.0
Miscellaneous	0.7	0.1	0.1	5.2	5.2
Forest wildfires and managed burning	0.5	0	0.1	0.7	4.2
Agricultural burning	0.1	0	0	0.2	0.8
Coal refuse burning	0	0.1	0	0	0.1
Structural fires	0.1	0	0	0	0.1
Miscellaneous organic solvent use	0	0	0	4.3	0
Total	19.6	29.6	21.6	29.6	103.8

Note: A zero indicates emissions of less than 50,000 metric tons per year.

Table 5-5 NATIONWIDE EMISSION ESTIMATES, 1973
(10^6 metric tons/year)

Source category	TSP	SO_x	NO_x	VOC	CO
Transportation	1.2	0.7	9.0	12.3	85.9
Highway vehicles	0.8	0.3	6.5	10.7	76.5
Non-highway vehicles	0.4	0.4	2.5	1.6	9.4
Stationary fuel combustion	6.5	23.1	12.3	1.5	1.4
Electric utilities	4.4	17.6	6.2	0.1	0.3
Industrial	1.8	3.7	5.2	1.3	0.6
Residential, commercial, and institutional	0.3	1.8	0.9	0.1	0.5
Industrial processes	10.3	6.3	0.7	9.7	8.2
Chemicals	0.2	0.6	0.2	2.4	2.7
Petroleum refining	0.1	0.8	0.4	1.0	2.2
Metals	2.1	4.0	0	0.2	2.3
Mineral products	6.4	0.7	0.1	0	0
Oil and gas production and marketing	0	0.1	0	3.0	0
Industrial organic solvent use	0	0	0	2.9	0
Other processes	1.5	0.1	0	0.2	1.0
Solid waste	0.6	0.1	0.2	1.0	3.6
Miscellaneous	0.6	0	0.1	5.2	4.4
Forest wildfires and managed burning	0.4	0	0.1	0.6	3.5
Agricultural burning	0.1	0	0	0.1	0.7
Coal refuse burning	0	0	0	0	0.1
Structural fires	0.1	0	0	0	0.1
Miscellaneous organic solvent use	0	0	0	4.5	0
Total	19.2	30.2	22.3	29.7	103.5

Note: A zero indicates emissions of less than 50,000 metric tons per year.

Table 5-6 NATIONWIDE EMISSION ESTIMATES, 1974
(10^6 metric tons/year)

Source category	TSP	SO_x	NO_x	VOC	CO
Transportation	1.2	0.7	8.6	11.5	81.7
Highway vehicles	0.8	0.3	6.3	10.0	73.3
Non-highway vehicles	0.4	0.4	2.3	1.5	8.4
Stationary fuel combustion	5.6	22.1	12.1	1.5	1.3
Electric utilities	3.8	17.2	6.3	0.1	0.3
Industrial	1.5	3.3	5.0	1.3	0.6
Residential, commercial, and institutional	0.3	1.6	0.8	0.1	0.4
Industrial processes	8.9	5.6	0.7	9.6	8.2
Chemicals	0.2	0.4	0.2	2.4	2.5
Petroleum refining	0.1	0.8	0.4	1.0	2.3
Metals	1.9	3.5	0	0.2	2.4
Mineral products	5.5	0.7	0.1	0	0
Oil and gas production and marketing	0	0.1	0	2.9	0
Industrial organic solvent use	0	0	0	2.9	0
Other processes	1.2	0.1	0	0.2	1.0
Solid waste	0.6	0	0.2	0.9	3.2
Miscellaneous	0.7	0	0.1	5.1	5.3
Forest wildfires and managed burning	0.5	0	0.1	0.8	4.5
Agricultural burning	0.1	0	0	0.1	0.6
Coal refuse burning	0	0	0	0	0.1
Structural fires	0.1	0	0	0	0.1
Miscellaneous organic solvent use	0	0	0	4.2	0
Total	17.0	28.4	21.7	28.6	99.7

Note: A zero indicates emissions of less than 50,000 metric tons per year.

Table 5-7 NATIONWIDE EMISSION ESTIMATES, 1975
(10^6 metric tons/year)

Source category	TSP	SO_x	NO_x	VOC	CO
Transportation	1.1	0.7	8.6	11.3	82.0
Highway vehicles	0.8	0.3	6.4	9.8	73.8
Non-highway vehicles	0.3	0.4	2.2	1.5	8.2
Stationary fuel combustion	5.0	20.8	11.5	1.4	1.1
Electric utilities	3.7	16.8	6.2	0.1	0.3
Industrial	1.1	2.6	4.5	1.2	0.5
Residential, commercial, and institutional	0.2	1.4	0.8	0.1	0.3
Industrial processes	6.5	4.6	0.7	9.2	7.3
Chemicals	0.2	0.3	0.2	2.1	2.2
Petroleum refining	0.1	0.8	0.4	1.0	2.4
Metals	1.4	2.7	0	0.2	1.8
Mineral products	3.7	0.6	0.1	0.1	0
Oil and gas production and marketing	0	0.1	0	2.9	0
Industrial organic solvent use	0	0	0	2.7	0
Other processes	1.1	0.1	0	0.2	0.9
Solid waste	0.5	0	0.1	0.8	2.9
Miscellaneous	0.6	0	0.1	4.2	3.6
Forest wildfires and managed burning	0.4	0	0.1	0.5	3.0
Agricultural burning	0.1	0	0	0.1	0.5
Coal refuse burning	0	0	0	0	0
Structural fires	0.1	0	0	0	0.1
Miscellaneous organic solvent use	0	0	0	3.6	0
Total	13.7	26.1	21.0	26.9	96.9

Note: A zero indicates emissions of less than 50,000 metric tons per year.

Table 5-8 NATIONWIDE EMISSION ESTIMATES, 1976
(10^6 metric tons/year)

Source category	TSP	SO_x	NO_x	VOC	CO
Transportation	1.1	0.8	9.4	11.6	85.1
Highway vehicles	0.8	0.4	7.0	10.0	76.6
Non-highway vehicles	0.3	0.4	2.4	1.6	8.5
Stationary fuel combustion	4.6	21.9	12.4	1.5	1.2
Electric utilities	3.3	17.7	6.7	0.1	0.3
Industrial	1.1	2.7	4.9	1.3	0.6
Residential, commercial, and institutional	0.2	1.5	0.8	0.1	0.3
Industrial processes	6.2	4.5	0.7	10.1	7.8
Chemicals	0.2	0.2	0.2	2.5	2.4
Petroleum refining	0.1	0.8	0.4	1.1	2.4
Metals	1.5	2.7	0	0.2	1.9
Mineral products	3.2	0.6	0.1	0.1	0
Oil and gas production and marketing	0	0.1	0	3.0	0
Industrial organic solvent use	0	0	0	3.0	0
Other processes	1.2	0.1	0	0.2	1.1
Solid waste	0.5	0	0.1	0.8	2.9
Miscellaneous	0.8	0	0.2	4.7	5.9
Forest wildfires and managed burning	0.6	0	0.2	0.9	5.3
Agricultural burning	0.1	0	0	0.1	0.5
Coal refuse burning	0	0	0	0	0
Structural fires	0.1	0	0	0	0.1
Miscellaneous organic solvent use	0	0	0	3.7	0
Total	13.2	27.2	22.8	28.7	102.9

Note: A zero indicates emissions of less than 50,000 metric tons per year.

Table 5-9 NATIONWIDE EMISSION ESTIMATES, 1977
(10^6 metric tons/year)

Source category	TSP	SO_x	NO_x	VOC	CO
Transportation	1.1	0.8	9.2	11.5	85.7
Highway vehicles	0.8	0.4	6.7	9.9	77.2
Non-highway vehicles	0.3	0.4	2.5	1.6	8.5
Stationary fuel combustion	4.8	22.4	13.0	1.5	1.2
Electric utilities	3.4	17.6	7.1	0.1	0.3
Industrial	1.2	3.2	5.0	1.3	0.6
Residential, commercial, and institutional	0.2	1.6	0.9	0.1	0.3
Industrial processes	5.4	4.2	0.7	10.1	8.3
Chemicals	0.2	0.2	0.2	2.7	2.8
Petroleum refining	0.1	0.8	0.4	1.1	2.4
Metals	1.3	2.4	0	0.1	2.0
Mineral products	2.7	0.6	0.1	0.1	0
Oil and gas production and marketing	0	0.1	0	3.1	0
Industrial organic solvent use	0	0	0	2.7	0
Other processes	1.1	0.1	0	0.3	1.1
Solid waste	0.4	0	0.1	0.7	2.6
Miscellaneous	0.7	0	0.1	4.5	4.9
Forest wildfires and managed burning	0.5	0	0.1	0.7	4.3
Agricultural burning	0.1	0	0	0.1	0.5
Coal refuse burning	0	0	0	0	0
Structural fires	0.1	0	0	0	0.1
Miscellaneous organic solvent use	0	0	0	3.7	0
Total	12.4	27.4	23.1	28.3	102.7

Note: A zero indicates emissions of less than 50,000 metric tons per year.

6. EMISSION DENSITY MAPS OF THE U. S.

This section describes the geographical variation in emission density across the continental United States for the mid-point of the decade - the base year 1975. Five shaded maps (Figures 6-1 through 6-5) are presented which display emission density estimates by county for total suspended particulate (TSP), sulfur oxides (SO_x), nitrogen oxides (NO_x), hydrocarbons (HC), and carbon monoxide (CO). These estimates were developed from data obtained from the National Emissions Data System. The maps were prepared by developing a separate computer drawn mask for the counties in each of four emission density classes. These masks were then photographically combined into a composite negative from which the final maps were produced.

Table 6-1 provides useful supplemental data on the total population, total land area, and average population density of the counties in each of the 5 emission density classes displayed on each map. For example, Table 6-1 indicates that 27% of the total U.S. population live in counties with average TSP emissions between 10 and 30 tons per square mile. These counties occupy 6% of the total U.S. land area and have an average population density of 327 persons per square mile. Note that emission density increases with increasing population density for each of the 5 pollutants. This relationship is confirmed by examination of Figures 6-1 through 6-5. Highly urbanized areas generally have high emission densities. This is particularly true for nitrogen oxides, hydrocarbons, and carbon monoxide which are the principal pollutants generated by automobiles. A discussion of the individual emission density maps follows.

6.1 TOTAL SUSPENDED PARTICULATE EMISSION DENSITY MAP

Figure 6-1 is a map of the United States with each county shaded according to its estimated TSP emission density. The major sources of TSP emissions in 1975 were electric utilities and industrial processes involving metals and mineral products (see Table 5-7). TSP emission densities are generally higher in the East than in the West. Table 6-1 indicates that approximately 14% of the total U.S. population live in areas with TSP emission densities exceeding 100 tons per square mile. More than half of the population reside in areas with TSP emission density greater than 10 tons per square mile. These areas represent 9% of the total land area of the continental U.S.

6.2 SULFUR OXIDES EMISSION DENSITY MAP

Figure 6-2 is a map of the United States with each county shaded according to its estimated SO_x emission density. SO_x emissions are high in areas characterized by heavy use of fossil fuels containing sulfur compounds; stationary fuel combustion by electric utilities and industrial power plants accounted for approximately 75% of the total 1975 SO_x emissions in the United States. Smelters contributed another 10% of the total 1975 emissions (See Table 5-7). The areas with high SO_x emission densities are located in many areas in the northeast and several isolated counties in the western U.S. where smelters are found. Table 6-1 indicates that 26% of the total U.S. population live in areas with SO_x emission densities exceeding 100 tons per square mile. Over half of the population live in areas with emission density greater than 10 tons/square mile; these areas represent 11% of the land area of the continental U.S.

6.3 CARBON MONOXIDE EMISSIONS DENSITY MAP

Figure 6-3 is a map of the United States with each county shaded according to its estimated CO emission density. High emission densities occur in most densely populated areas. This finding is consistent with emission inventory data in Table 5-7 which show that transportation-related sources accounted for approximately 85% of the total CO emissions in 1975. Major metropolitan areas typically have high traffic volume and high CO emission densities. Table 6-1 indicates that approximately 42% of the U.S. population live in areas with emission densities exceeding 300 tons per square mile. Over half of the population live in areas with CO emission densities exceeding 100 tons per square mile; these areas account for 6% of the land area of the continental U.S.

6.4 HYDROCARBON EMISSION DENSITY MAP

Figure 6-4 is a map of the United States with each county shaded according to its estimated HC emission density. The major sources of HC emissions are highway vehicles, organic solvent use, and oil and gas production. These three sources accounted for approximately 71% of the total HC emission in 1975 (see Table 5-7). The areas with high SO_x emission densities resulting from one or more of these sources are the Northeast Corridor extending from Washington, D.C. to Boston, Massachusetts; Los Angeles; and areas along the Gulfcoast. HC emission densities are generally higher in the northeast and north central states than the rest of the Nation. Table 6-1 indicates that approximately 39% of the U.S. population live in areas with HC emission densities exceeding 100 tons per square mile. Over half of the population live in areas where HC emissions are greater than 30 tons/square mile; these areas represent 6% of the land area of the continental U.S.

6.5 NITROGEN OXIDES EMISSION DENSITY MAP

Figure 6-5 is a map of the United States with each county shaded according to its estimated NO_x emission density. The principal sources of NO_x emissions are highway vehicles, electric utilities, and industrial power plants. These three sources accounted for approximately 82% of the total NO_x emissions in 1975 (see Table 5-7). Areas with high NO_x emission densities include many of the large metropolitan areas across the U.S. Emission densities are generally lower in areas with lower population density. Table 6-1 indicates that approximately 29% of the total U.S. population live in areas with NO_x emission densities exceeding 100 tons per square mile. Over 50% of the population lives in areas where NO_x emission density is greater than 30 tons/ square mile; these areas represent only 5% of the land area of the continental U.S.

Table 6-1. POPULATION, LAND AREA, AND POPULATION DENSITY OF COUNTIES IN INDICATED EMISSION DENSITY CLASS

1975 Emission Density[a]	% of Total Population	% of Total Land Area	Average Population Density[b]
TSP			
> 100	14	1	1824
30 - <100	15	2	509
10 - < 30	27	6	327
1 - < 10	35	37	65
<1	9	55	11
SO_x			
> 100	26	2	829
30 - <100	20	4	318
10 - < 30	13	5	166
1 - < 10	24	19	86
<1	17	69	16
CO			
> 300	42	2	1571
100 - <300	18	4	337
30 - <100	21	14	103
10 - < 30	14	28	34
<10	5	53	6
HC			
> 100	39	2	1658
30 - <100	20	4	368
10 - < 30	18	11	118
3 - < 10	16	28	39
<3	6	56	7
NO_x			
> 100	29	1	17535
30 - <100	25	4	430
10 - < 30	18	8	161
3 - < 10	18	23	54
<3	10	64	10

[a] Tons per square mile.
[b] People per square mile.

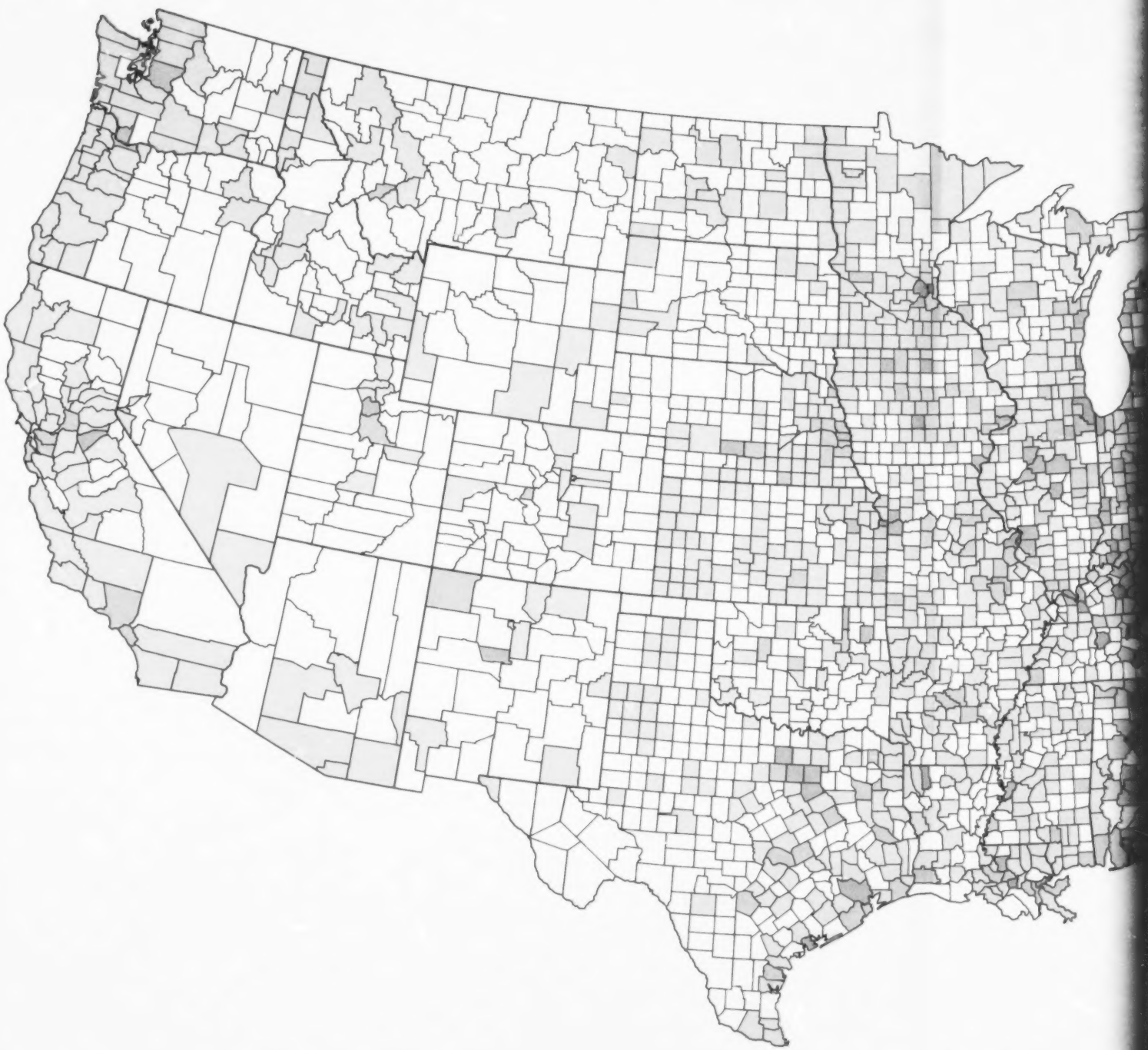
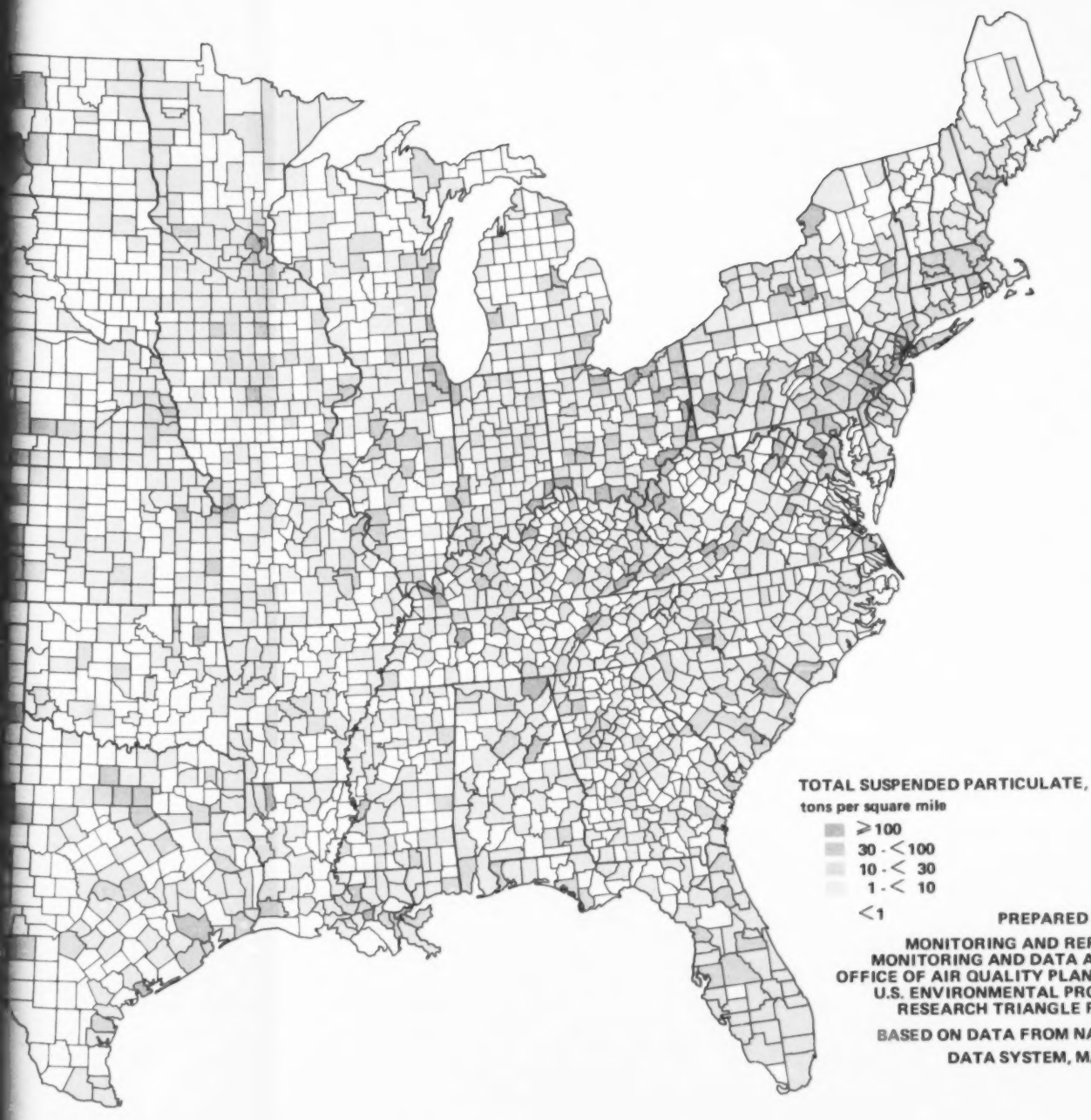


Figure 6-1. Total suspended particulate emission density by county.



l suspended particulate emission density by county.

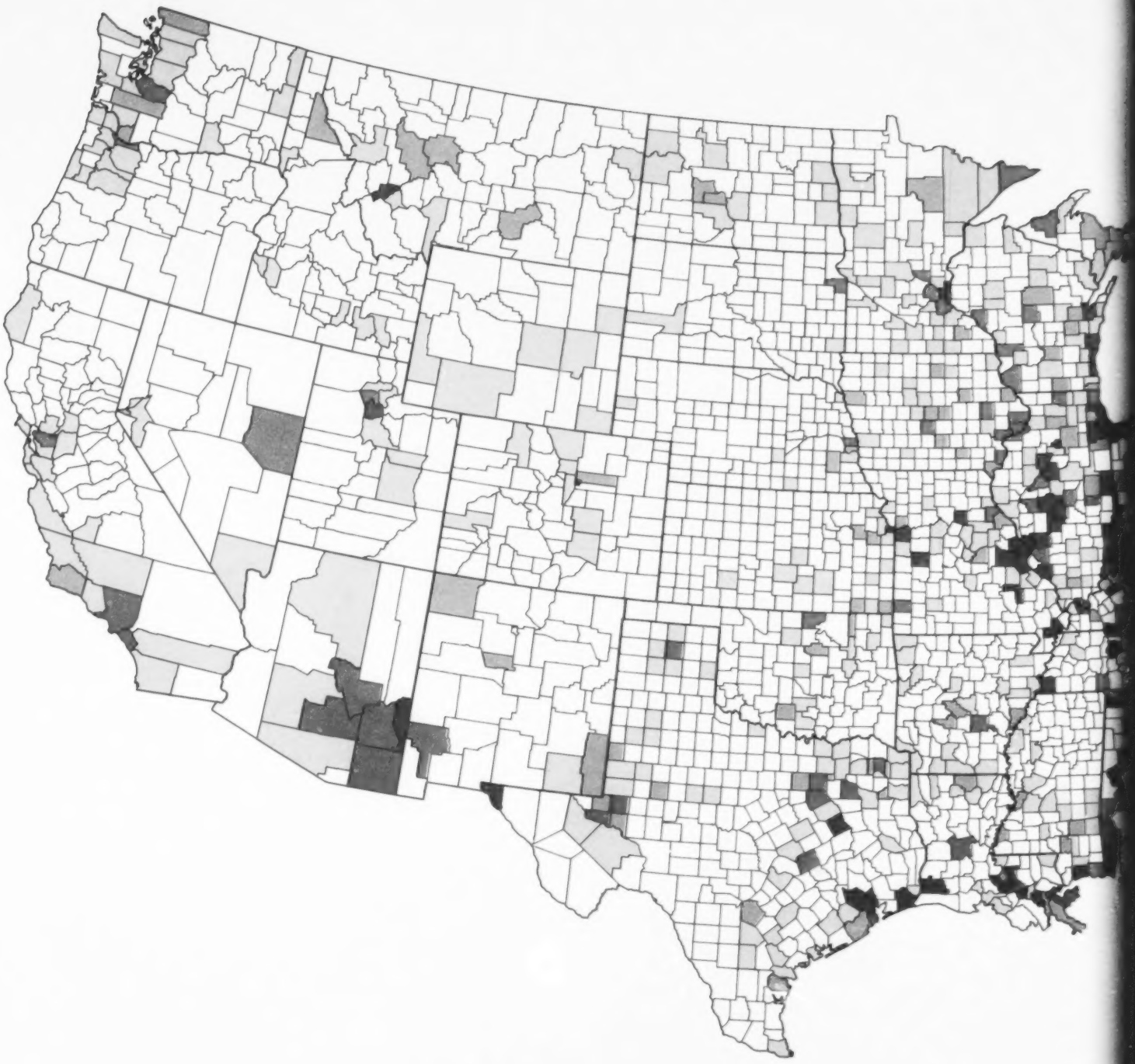
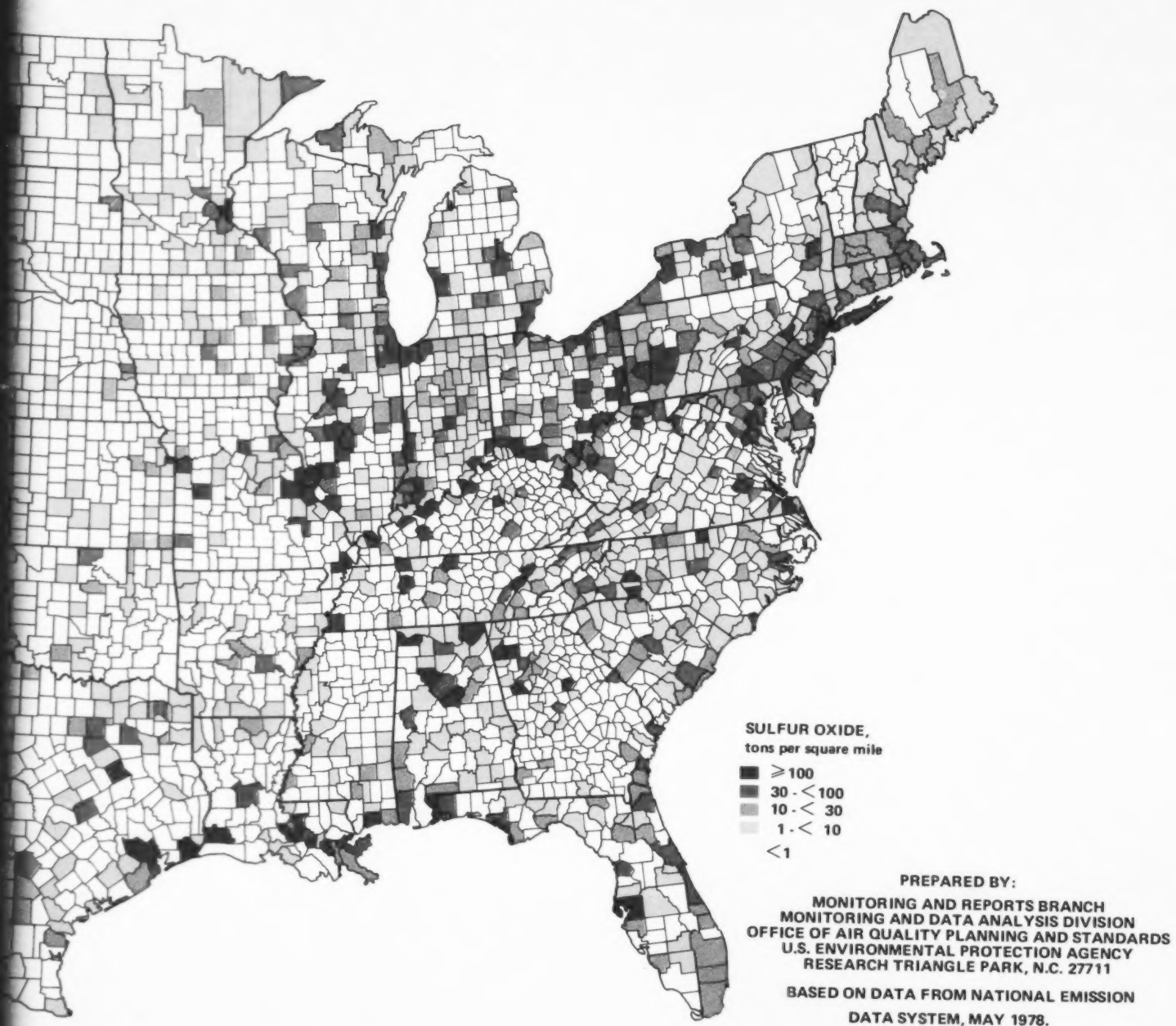


Figure 6-2. Sulfur oxide emission density by county.



Sulfur oxide emission density by county.

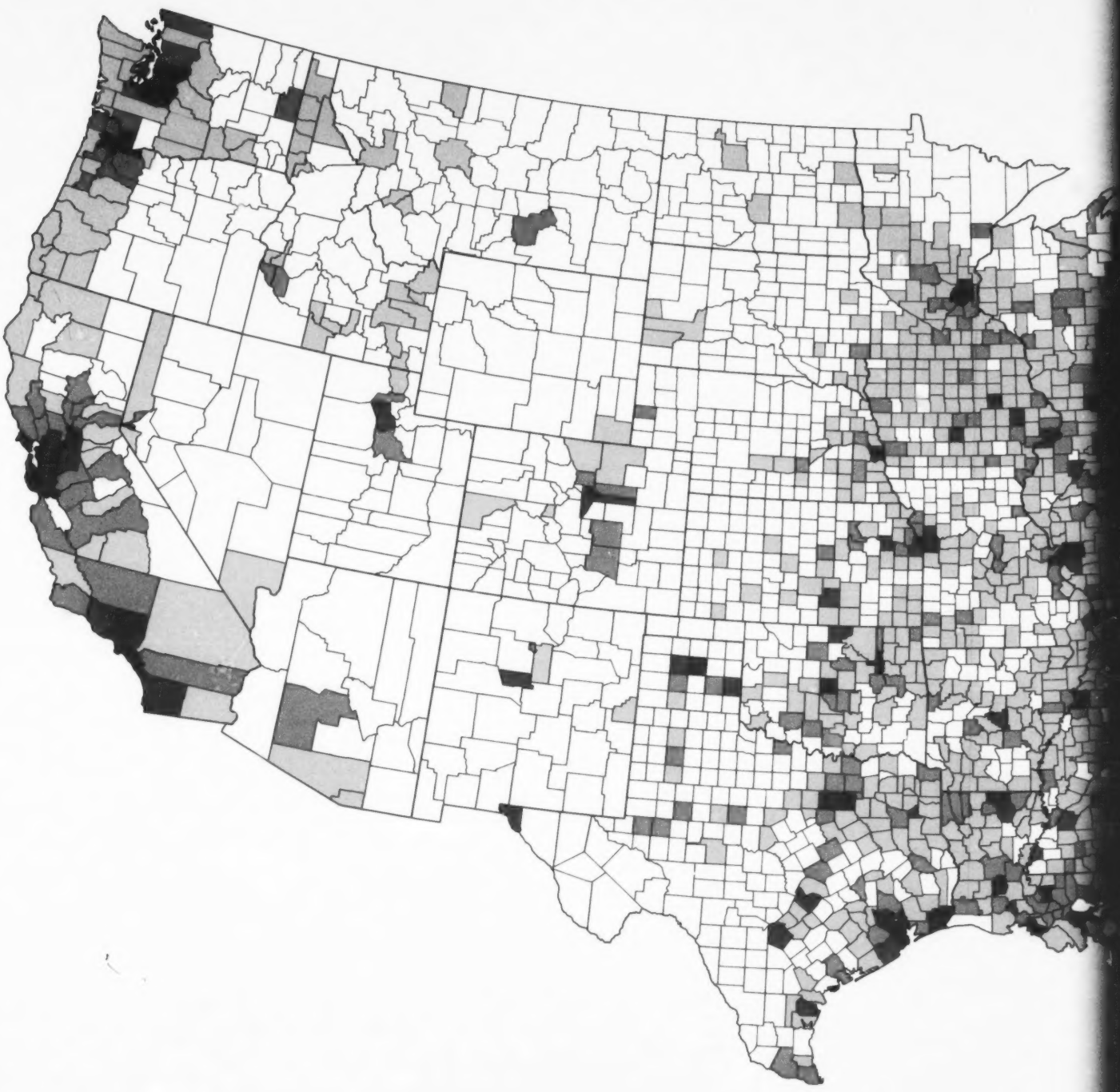
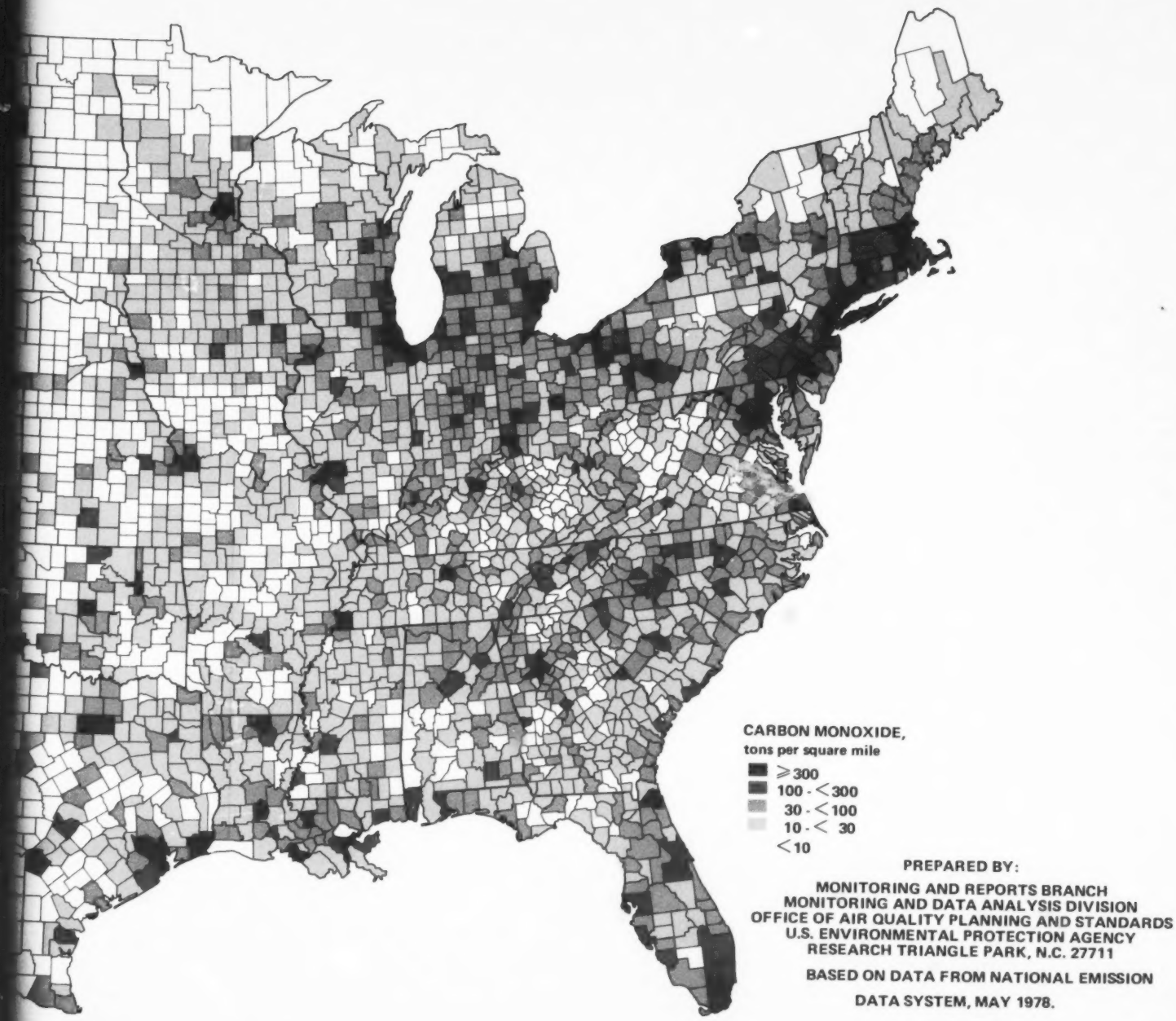


Figure 6-3. Carbon monoxide emission density by coun



on monoxide emission density by county.

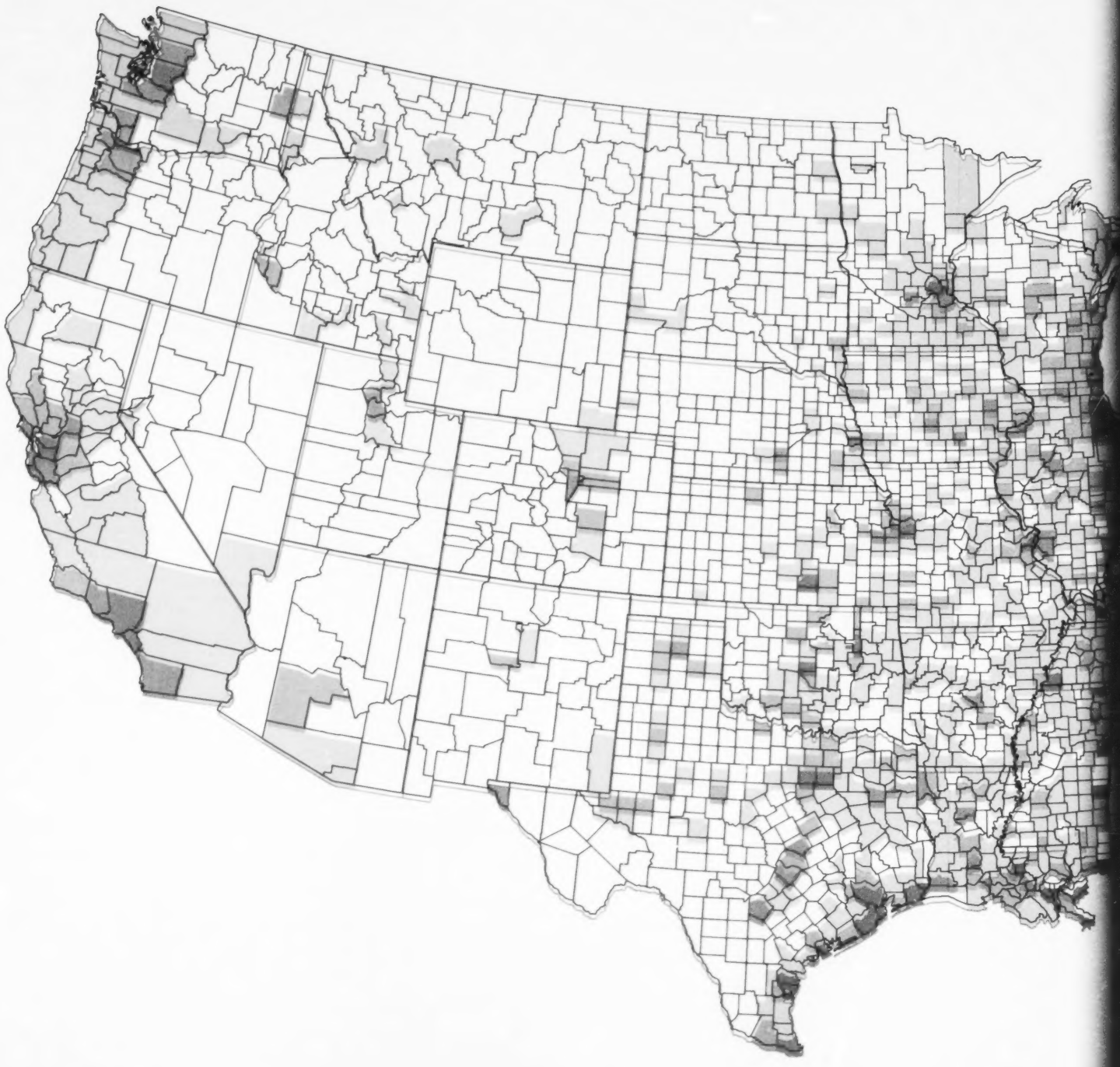
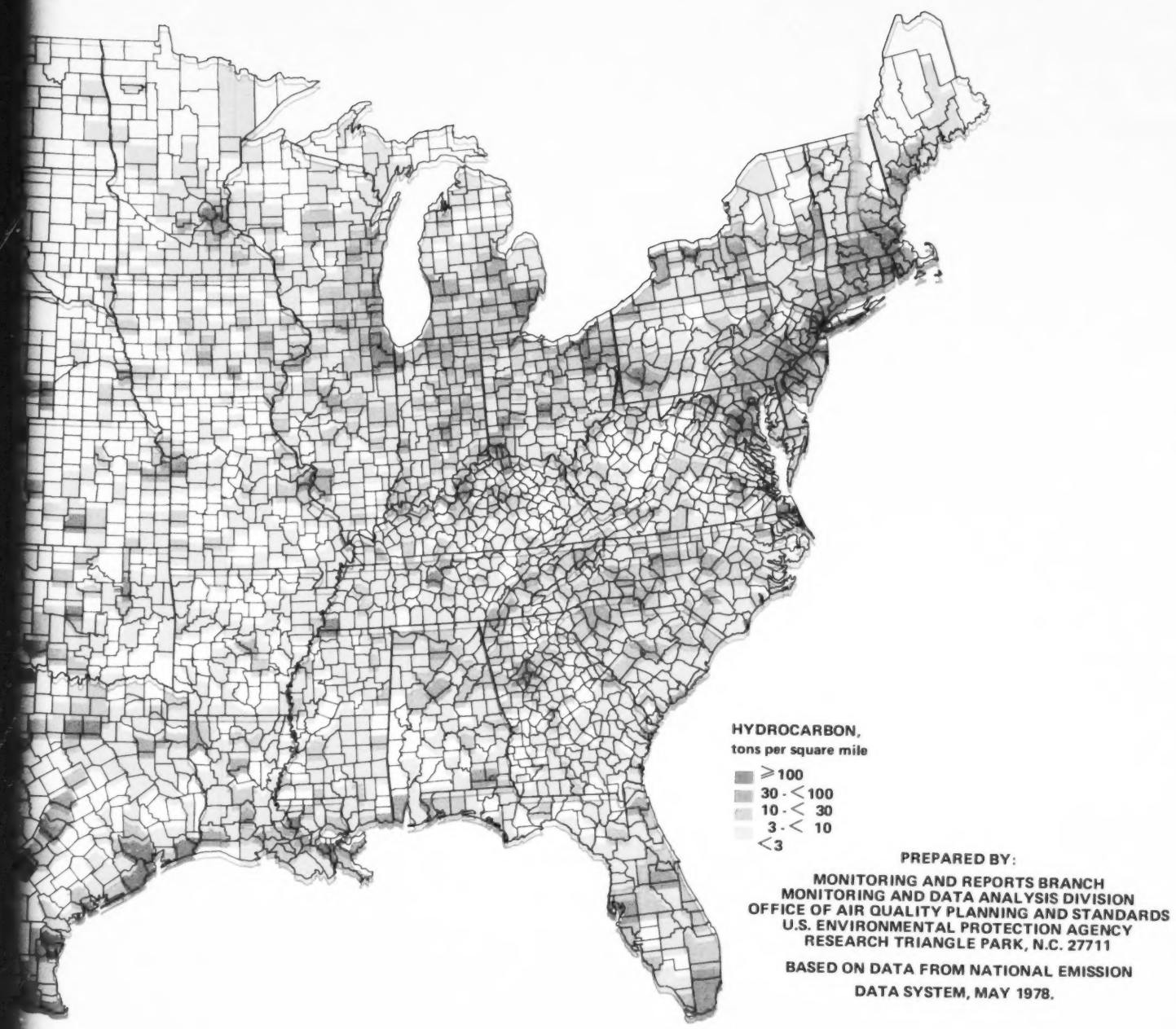


Figure 6-4. Hydrocarbon emission density by county.



drocarbon emission density by county.

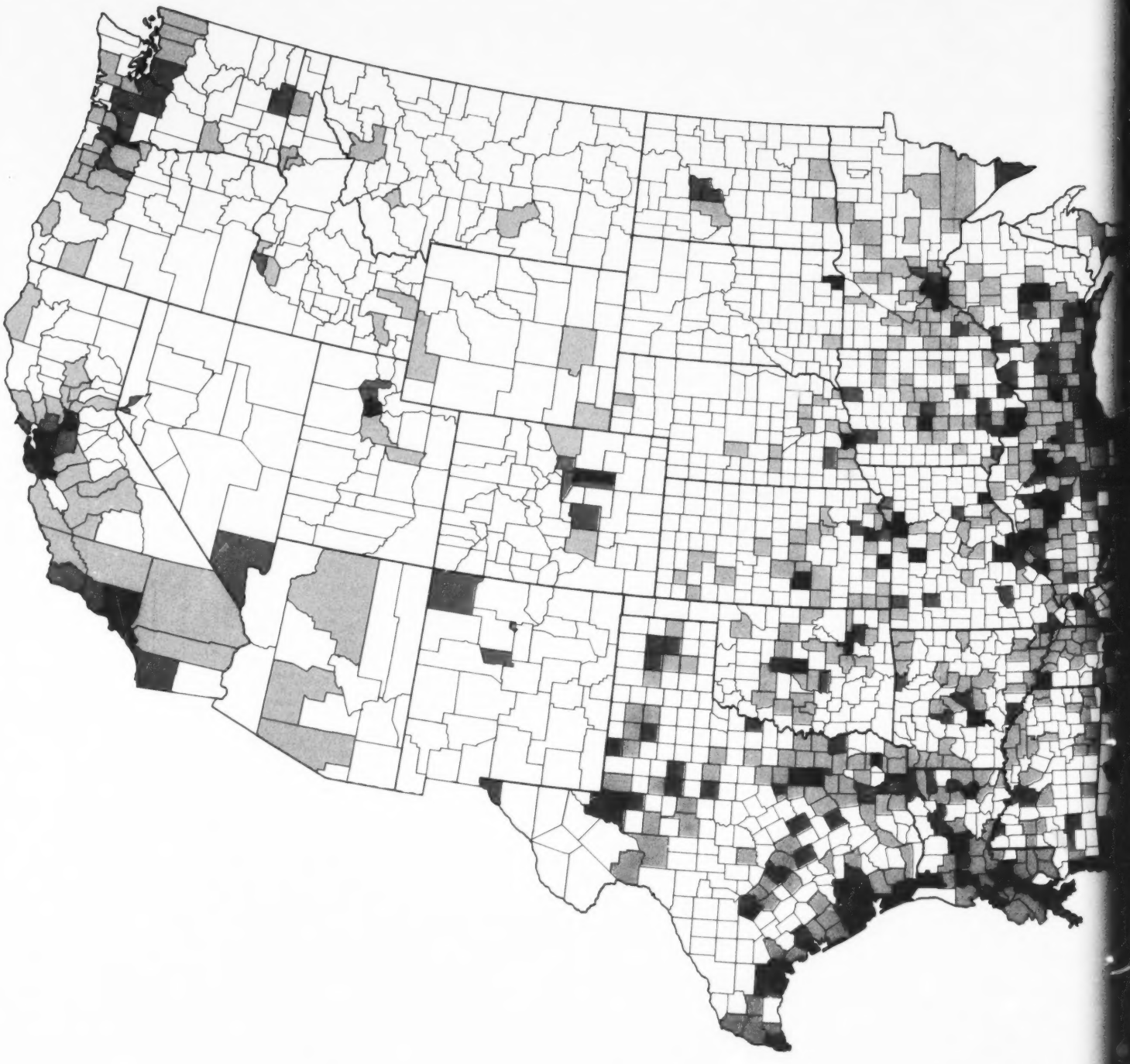
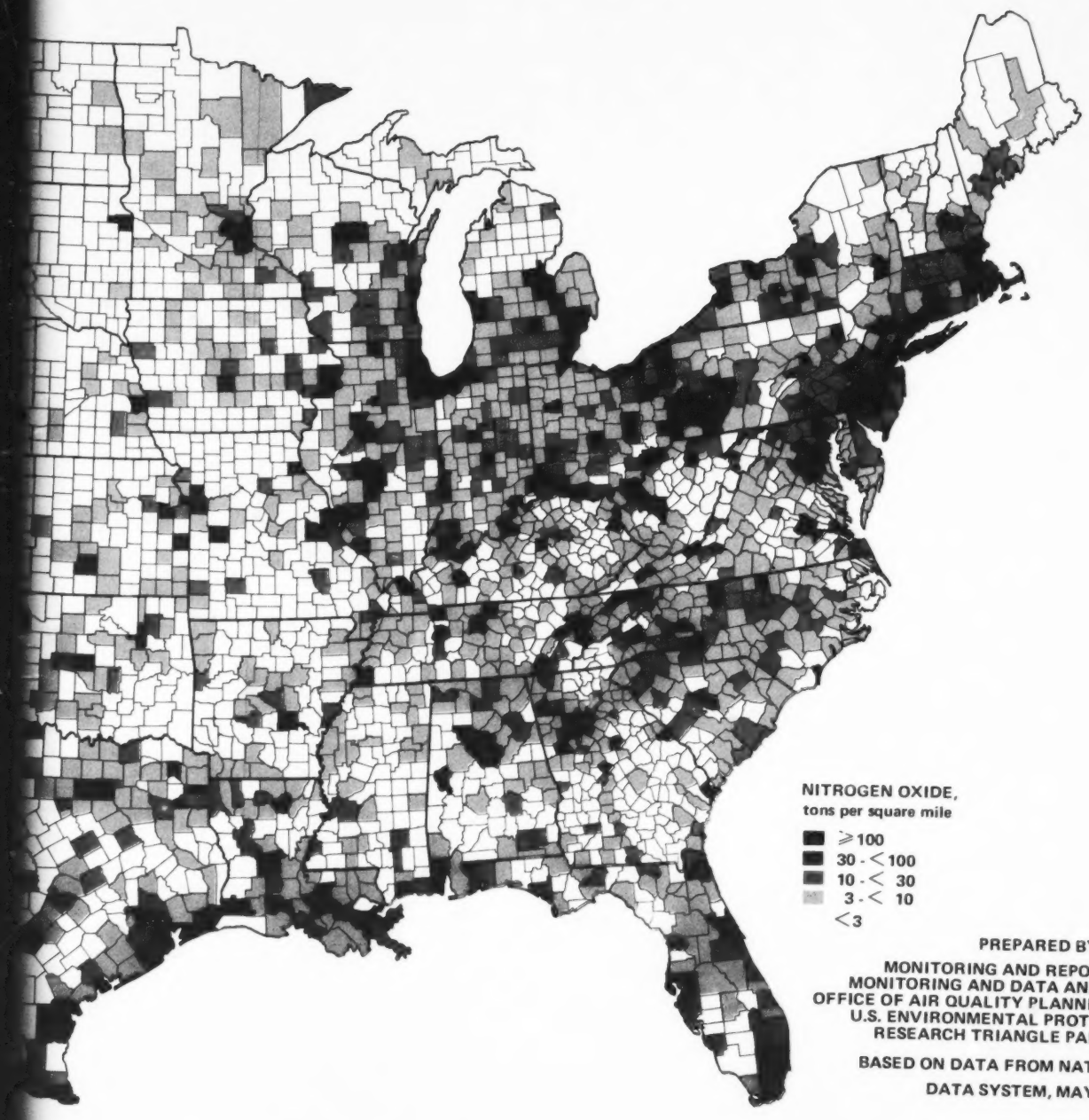


Figure 6-5. Nitrogen oxide emission density by county.



gen oxide emission density by county.